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Lingcod stock assessment and recommended yield options for 2001

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Abstract

Lingcod stocks were examined for the Strait of Georgia, southwest and northwest coasts of Vancouver Island, Queen Charlotte Sound, Hecate Strait and the west coast of the Queen Charlotte Islands. Interpretation of stock condition relies on recent trends in catch statistics and limited age composition data from the commercial trawl fishery.

In the Strait of Georgia (Area 4B), a catch per unit effort index based on creel survey data has increased in recent years, but not to levels that indicate an improvement in stock conditions. A continued strategy for rebuilding of lingcod stocks in Area 4B is recommended.

Off the southwest coast of Vancouver Island (Area 3C), a 25% Qualified catch per unit effort index (CPUE) based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. In addition, the age proportion data available for the trawl fishery did not indicate that either a strong cohort or a series of strong cohorts were entering the fishery. We have no new information to revise the existing yield recommendation that total removals do not exceed 1000 tonnes.

Off the northwest coast of Vancouver Island (Area 3D), a 25% Qualified CPUE based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. There are no age proportion data to provide information on cohort strength in the fishery. We have no new information to revise the existing yield recommendation of 400-800 tonnes.

In Queen Charlotte Sound (Areas 5A/B),), a 25% Qualified CPUE based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. Age proportion data available for the trawl fishery did not indicate that a either a strong cohort or a series of strong cohorts were entering the fishery. We have no new information to revise the existing yield recommendation of 1100-2200 tonnes. However, it should be noted that this yield range was based on a model that used inaccurate age data and therefore growth and mortality estimates were not well determined.

For the areas in Hecate Strait (Areas 5C/D) and west coast of the Queen Charlotte Islands (Area 5E), there is no new information to revise the existing yield level of 1000 tonnes for all three areas combined.

Résumé

La présente étude porte sur les stocks de morue-lingue de Georgia Strait, des côtes sud-ouest et nord-ouest de l'île de Vancouver, Queen Charlotte Sound, Hecate Strait et de la côte ouest des îles de la Reine-Charlotte. L'interprétation de l'état des stocks repose sur les récentes tendances des statistiques sur les prises et des données limitées sur la composition des prises selon l'âge issues de la pêche commerciale au chalut.

Dans Georgia Strait (secteur 4B), l'indice des captures par unité d'effort calculé à partir de données de relevé des prises a augmenté dans les dernières années, mais non à des niveaux indiquant une amélioration de l'état des stocks. Une stratégie soutenue de rétablissement des stocks de morue-lingue dans le secteur 4B est recommandée.

Au large de la côte sud-ouest de l'île de Vancouver (secteur 3C), un indice restrictif des captures par unité d'effort (CPUE) de 25 %, tiré des prises admissibles au chalut de mai à septembre, n'a pas révélé de changements récents dans l'abondance. En outre, les données sur la composition des prises selon l'âge issues de la pêche au chalut n'indiquent pas qu'une cohorte ou une série de cohortes abondantes sont en voie d'être recrutées à la pêche. Aucun nouveau renseignement n'est disponible pour réviser la recommandation actuelle sur le rendement à l'effet que les prises totales ne dépassent pas 1 000 t.

Au large de la côte nord-ouest de l'île de Vancouver (secteur 3D), un indice restrictif des captures par unité d'effort (CPUE) de 25 %, tiré des prises admissibles au chalut de mai à septembre, n'a pas révélé de changements récents dans l'abondance. L'absence de données sur la composition des prises selon l'âge ne permet pas d'établir l'abondance des cohortes dans la pêche. Aucun nouveau renseignement n'est disponible pour réviser la recommandation actuelle sur le rendement de 400 à 800 t.

Dans Queen Charlotte Sound (secteurs 5A et B), un indice CPUE restrictif de 25 %, tiré des prises admissibles au chalut de mai à septembre, n'a pas révélé de changements récents dans l'abondance. Les données sur la composition des prises selon l'âge issues de la pêche au chalut n'indiquent pas qu'une cohorte ou une série de cohortes abondantes sont en voie d'être recrutées à la pêche. Aucun nouveau renseignement n'est disponible pour réviser la recommandation actuelle sur le rendement de 1 100 à 2 200 t. On doit toutefois noter que cette gamme de rendement repose sur un modèle fondé sur des données inexactes sur l'âge et que, par conséquent, les estimations de la croissance et de la mortalité ne sont pas précises.

Dans le cas des secteurs de Hecate Strait (secteurs 5C et D) et de la côte ouest des îles de la Reine-Charlotte (secteur 5E), on ne dispose pas de nouveaux renseignements permettant de réviser le niveau de rendement actuel de 1 000 t, tous les trois secteurs confondus.

1.0 GENERAL INTRODUCTION

We present stock assessments for lingcod throughout British Columbia waters. Tables of lingcod catch for the commercial fisheries, including total landings, qualified catch and effort along with catch per unit effort (CPUE) are updated to the end of the calendar year of 1999. Since sources of information for historical landings vary, we have provided a list of these sources in Appendix I (Table A1). In order to provide a source of information for general lingcod biology and a history of the fishery, separate sections for these topics have been included in this document. In addition, information regarding climate-ocean regimes in the north Pacific has been included to provide a reference section on recent research on decadal-scale dynamics of marine systems. We use information on recent trends in catch statistics, age composition of the commercial catch, creel survey information where appropriate, and consideration of climate-ocean regimes to provide interpretations of present stock conditions. Pertinent details of lingcod management and quota history have been summarized in Appendix II.

2.0 INTRODUCTION TO LINGCOD AND THE FISHERY IN BRITISH COLUMBIA

2.1 General Biology

Lingcod (*Ophiodon elongatus*) are unique to the west coast of North America and occur from Baja, California to the Shumagin Islands, Alaska. They inhabit nearshore waters and are commonly found along the bottom at depths ranging from 3 to 400 m, with most found in rocky areas 10 to 100 m. Lingcod are considered to be a non-migratory species. Tagging studies in the 1980s off the west coast of Vancouver Island indicated that 95% of the lingcod recovered in the first and second year after tagging tended to be within 10 km of their release site (Cass et al. 1990). Concurrent tagging studies in the Strait of Georgia indicated very little mixing between offshore and inshore stocks (Cass et al. 1990).

Female lingcod mature between ages 3 to 5 years at a mean size of 61-75 cm, while males mature at age 2 at a mean size of 50 cm (Cass et al. 1990). Males can be distinguished externally from females by the presence of a short, broadly conical papilla anterior to the anal opening (Wilby 1937). In Canadian waters, spawning begins in December and continues into March with the peak spawning activity in late January to early February (Wilby 1937; Low and Beamish 1978). Seasonal migration to nearshore spawning sites begins in October, with the males migrating before the females (Cass et al. 1990). Nesting sites are typically in rock crevices or ledges where there are strong currents (Low and Beamish 1978). Lingcod are one of the few marine fishes that exhibit parental care for incubating eggs. The males remain within 1 meter of an egg mass and exhibit aggressive behaviour to larger predators such as kelp greenling (*Hexagrammos decagrammus*) and striped seaperch (*Embiotica lateralis*) which typically feed on lingcod eggs and larvae (Low and Beamish 1978). Egg mortality due to predation can be very significant, and nests that are left unguarded, or that have males removed from them, do not survive to hatching (Low and Beamish 1978).

Lingcod begin to hatch in early March through late April, at a length of about 6-10 mm (Phillips and Barraclough 1977). For the first few weeks, the larvae are planktonic and are

found in the upper 3 m of the water column during the day (Phillips an Barraclough 1977), but migrate to deeper waters at night (Cass et al. 1990). By about mid-May the post-larval lingcod are approximately 50-70 mm and have become demersal, inhabiting areas near kelp or eelgrass beds (Phillips and Barraclough 1977). By September, the young-of-year are found in a wider range of flat bottom areas, and by age 2 begin to inhabit similar substrates as older lingcod (Cass et al. 1990). Typically, larger lingcod inhabit deep banks and reefs, while smaller lingcod inhabit shallow waters and banks (Forrester 1973).

Growth during the first years of life is rapid and up to age 2 it is similar for males and females with both reaching an average length of 45 cm (Cass et al. 1990). After age 2, females grow faster than males, with the growth of males tapering off at about age 8 and females continuing to grow rapidly until about age 12-14. For waters off the west coast of Canada, the maximum age recorded for lingcod was 14 years for males and 20 years for females. Females reach lengths in excess of 100 cm, while males rarely exceed lengths of 90 cm.

As evident from their huge gaping mouths and long, pointed teeth, lingcod are voracious predators. As larvae, lingcod feed on calanoid copepods, decapod larvae, amphipods, euphausiids and larval herring (*Clupea harengus*) (Phillips and Barraclough 1977). As the young-of-year move inshore and begin a demersal life, their diet switches from zooplankton to juvenile herring (Phillips and Barraclough 1977). Juveniles consume herring, Pacific sand lance (*Ammodytes hexapterus*), flatfish (Pleuronectidae), shiner perch (*Cymatogaster aggregata*) and walleye pollock (*Theragra chalcogramma*) (Phillips and Barraclough 1977; Cass et al. 1990). Some invertebrates such as shrimp (*Neomysis macrops*) and prawn (*Pandalus danae*) are consumed (Cass et al. 1990). Adults feed mostly on herring and Pacific hake (*Merluccius productus*), but are predators of many fish and invertebrates including Pacific sand lance, flatfish, rockfish (*Sebastes*), spiny dogfish (*Squalus acanthias*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), Pacific tomcod (*Microgadus proximus*), salmon (*Oncorhynchus*), crabs, shrimps, squid and octopus (Cass et al. 1990). Aside from the early larval stage, lingcod themselves have few predators. The predators of adult lingcod are mainly marine mammals including sea lions and harbour seals (Cass et al. 1990).

2.2 History of the Fishery

Commercial fishing for lingcod in British Columbia began around 1860 (Cass et al. 1990). Lingcod catch data has been recorded from a variety of sources since 1927 (Appendix I Table A1). Prior to 1927, lingcod landings were grouped with other groundfish species into a 'cod' category, though there is some suggestion that lingcod comprised almost all of the catch (Ketchen et al. 1983). Between 1900 and the 1940s, lingcod was ranked fourth in commercial importance after salmon, herring and sardines, and was the main source of fresh fish throughout the year (Cass et al. 1990). Prior to the 1940s, the fishery was dominated by the Strait of Georgia hook and line fishery. By the 1940s, most areas off the British Columbia coast were being exploited by the trawl fishery, and since the 1960s, trawl landings have dominated (Appendix I Table A2, Figure 1). In the 1930s and 1940s, hook and line landings ranged from about 2,100 to 4,300 tonnes, but had dropped to less than 200 tonnes by the mid-1950s (Appendix I Table A2, Figure 1). At the same time, trawl landings gradually increased and by the 1950s, averaged over 2,400 tonnes (Appendix I Table A2, Figure 1). In waters off southwestern Vancouver Island (Major Statistical Area 3C, Figure 2), United States trawlers also began to fish lingcod in the

1940s. With the declaration of Canada's 200 mile Canadian Fishing Zone in 1977, US trawl catches in Canadian waters dwindled and had ceased completely by 1980 (Appendix I Table A2).

The commercial lingcod fishery has been subject to a variety of management measures since at least the 1920s (Appendix II Table A3). Since the 1920s, the lingcod fishery has been subject to winter closures in order to protect spawning fish and nest-guarding males. Commercial closures were initially in place from December to February in the Gulf Island region of the Strait of Georgia (Area 4B, Figure 2). In 1979, after further studies into spawning and nest guarding behaviour, this winter closure was extended to November 15 to April 15, and applied to the entire Strait of Georgia. In 1987, winter closures were implemented for all commercial fisheries off the west coast of Vancouver Island. Closures were from January 1 to April 15 in the offshore portions of Areas 3C and 3D and in the west coast Vancouver Island portions of Area 5A, and from November 15 to April 15 in the inshore portions of Areas 3C and 3D. In 1988 the closures were extended to November 15 to April 15 for the entire west coast of Vancouver Island. Since 1942, a coastwide size limit of 58 cm (head-on) on retained lingcod was applied to the commercial fishery. This was extended to 65 cm for Area 4B in 1989, and for the whole coast in 1996. The trawl fishery changed substantially in 1996, with the introduction of onboard vessel observers, bycatch limits for halibut, and the requirement that all catches of quota species, including discards, would be counted against vessel period limits. The winter closure for the trawl fishery was removed in 1996.

The recreational fishery has also been subject to winter closures and size restrictions (Appendix II Table A3; W. Grider, pers. comm. Regulations Unit, Fisheries Management Branch, Fisheries and Oceans Canada, 555 West Hastings Street, Vancouver, BC, V6B 5G3). In 1979, a winter closure (November 15 to April 15) was initiated for the recreational fishery in the Strait of Georgia (Area 4B), and was extended to October 1 to May 31 in 1991. A similar winter closure was initiated for the west coast of Vancouver Island (Areas 3C and 3D) in 1992. In 1991, a size limit of 65 cm was applied to lingcod retained in the Area 4B recreational fishery, and this was extended to the west coast of Vancouver Island (Areas 3C and 3D) in 1999. There is no winter closure or size limit for recreationally caught lingcod in other areas of the coast (Areas 5A to 5E). Presently, there are daily catch limits of 1 for Area 4B and 3 for all other areas, with an annual limit of 10 for Area 4B only.

3.0 NORTH PACIFIC CLIMATE-OCEAN REGIMES

Climate-ocean systems of the north Pacific exhibit relative stability on decadal-scales, with several possible steady states. Switches between decadal-scale steady states are abrupt, often occurring within one year. The periods of steady states have become known as regimes, while the switches between states are called regime shifts. Regime shifts have been observed in such climate-ocean systems as the Aleutian Low pressure system (Beamish and Bouillon 1993; Beamish et al. 1999); the atmospheric circulation patterns associated with the westerlies (King et al. 1998); Pacific-wide spatial patterns in sea surface temperatures (Mantua et al. 1997); the Arctic atmospheric system (Overland et al. 1999); and the mixed layer depth (Polovina et al. 1994). Within the last 100 years, regime shifts have occurred around 1925 (Minobe 1997), 1947 (Francis and Hare 1994), 1977 (Ebbesmeyer et al. 1991; Beamish and Bouillon 1993) and 1989 (Beamish et al. 1999; Watanabe and Nitta 1999). Presently, there is

suggestion that a regime shift occurred around 1997, manifested in the winter of 1998 (McFarlane et al. 2000; Hare and Mantua 2000).

While the global mechanisms for these north Pacific regime shifts have not been identified, the effects of Pacific basin-wide regime shifts have been observed in regional variables (Ebbesmeyer et al. 1991; Hare and Mantua 2000). Beamish et al. (2000) provide examples for British Columbia regional variables, such as river discharge, atmospheric pressure systems and circulation patterns and coastal sea surface temperatures. More importantly for fisheries science, synchronous shifts have been observed in the productivity patterns of major commercial species such as Pacific salmon (*Oncorhynchus* spp., - Beamish and Bouillon 1993; Hare and Francis 1995), Pacific sardines (*Sardinops sagax*, - Kawasaki and Omori 1988), tuna (*Thunnus thynnus*, - Polovina 1996), Pacific halibut (*Hippoglossus stenolepis*, - Clark et al. 1999) and sablefish (*Anoplopoma fimbria*, - King et al. 2000a). Off the west coast of Canada, various pelagic and demersal species have exhibited changes in abundance, recruitment, and distribution that are synchronous with regime shifts (McFarlane et al. 2000). McFarlane et al (2000) noted that key Canadian groundfish species experienced average to above average year class success during the 1977 to 1988 regime. Conversely, year class success tended to be average to below average during the 1989 to 1997 regime. Given the developing evidence for the impact of regime shifts on commercially exploited species, decadal-scale dynamics need to be acknowledged in stock assessment and fisheries management. For the period in which there are catch and effort data for the lingcod fishery (i.e. 1954-1999), regime shifts occurred in 1977 and 1989 with a recent one likely to have occurred in 1998.

4.0 INSHORE LINGCOD

4.1 Strait of Georgia (Area 4B)

4.1.1 Fishery and Management

The commercial fishery for lingcod in the Strait of Georgia began in the mid-1800s. A quota was never implemented, but due to conservation concerns, the commercial fishery for lingcod in Area 4B was closed in 1990 and has remained closed, with the exception of portions of Management Areas 12 and 20. Queen Charlotte Strait (Management Subareas 12-7, 12-9, 12-10, 12-13) and Juan de Fuca Strait west of Sheringham Point (Management Subareas 20-1, 20-2, 20-3, 20-4) remain open to both the trawl and hook and line fisheries because populations within these subareas are considered to be part of either the Queen Charlotte Sound (Area 5A, Figure 2) population or the south west coast of Vancouver Island (Area 3C) population (Richards and Yamanaka 1992). Historically, catches in Management Areas 12 and 20 have been reported with Area 4B statistics. A winter closure is in place from November 15 to May 14 for the trawl fishery and November 15 to June 30 for the line fishery in Management Subareas of Statistical Areas 12 and 20.

Historically, lingcod were commercially exploited primarily by the hook and line fishery, but between 1940 and 1990, a small portion of the total landings (about 10% on average) were from the trawl fishery (Figure 3). Since the commercial closure in 1990, catch is still reported for Area 4B (Figure 3), but this reflects catches in the open subareas in Areas 12 and 20.

Presently, lingcod in Area 4B are exploited by the recreational fishery, and are subject to a size limit of 65 cm (head on) and a winter closure from November 1 to April 30. There is a daily retention limit of 1, and an annual limit of 10 lingcod caught in the recreational fishery.

4.1.2 Catch Statistics

Since the closure of the commercial fishery, the only ongoing source of data for abundance indicators is the Strait of Georgia Creel Survey for the recreational fishery, which has been conducted annually since 1980. The Strait of Georgia Creel Survey covers the majority of area 4B, with the exception Johnstone Strait. Haist (1995) reviewed a number of abundance indices derived from interview data available from the creel survey program. Haist (1995) concluded that significant correlation between recreational fishery based indices and historical commercial catch rates (CPUE) supported the use of recreational fishery data to assess trends in stock abundance. Three recreational fishery indices had high correlations with the commercial CPUE: an index using total lingcod caught and number of fishing trips not directed at lingcod and two indices based on sub-area models. Since all three had similar correlations with the commercial CPUE ($r=0.86$, 0.87 and 0.85 respectively), we have chosen to use only the index based on interview records not directed at lingcod since this information is readily available.

The derivation of the index from interview data is described in Haist (1995). Information on species directed effort is available only since 1984. Since changes in the amount of effort directed to lingcod catches could influence the relationship between catch rates and stock abundance, effort was calculated as the number of interview records (i.e. fishing trips) for which lingcod was not the targeted species (Haist 1995). Catch per record was calculated as total lingcod caught (kept and released) from all interview records divided by the number of fishing trips without directed lingcod effort (Table 1). Since 1984, the catch of lingcod has been decreasing along with the number of interview records without lingcod effort (Table 1). However the catch per record was relatively stable from 1985-1995, with a recent increase in 1996-1999 to levels similar to 1984 (Table 1). The drop in the number of interview records in recent years does not reflect a reduction in sampling effort by the creel survey program, but rather a reduction in the number of recreational fishers (R. Nagtegaal, pers. comm., Stock Assessment Division, Science Branch, Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, V9R 5K6). Since 1996, the catch per record index has increased to levels that are comparable to values in the mid-1980s. However, it is important to note that the level of abundance for lingcod in the mid-1980s was severely depressed and warranted conservation concerns. Therefore, the recent increase in catch per record index does not indicate that lingcod have reached levels of abundance that do not warrant conservation concerns. In 1991, the number of kept lingcod dropped dramatically in response to the increased size limit implemented that year (Table 1). There was a corresponding increase in the number of lingcod released. Since 1991, the relative number of kept lingcod has remained fairly constant, indicating that there has not been an increased availability of lingcod greater than 65 cm.

The Strait of Georgia creel survey program provides expanded catch estimates for targeted species based on interview data and aerial surveys. In 1999 (April-October inclusive), the estimated number of retained lingcod in the Strait of Georgia recreational fishery was 3,601 pieces (L. Nagy, pers. comm., Stock Assessment Division, Science Branch, Fisheries and Oceans Canada, 555 West Hastings Street, Vancouver, British Columbia, V6B 5G3). As noted

earlier, this creel estimate is for the majority of area 4B with the exception of Johnstone Strait. Recreational catches are monitored in Johnstone Strait by the North Vancouver Island Creel Survey program. For 1999 (July-September inclusive), the estimated catch for retained lingcod in Johnstone Strait was 2,056 pieces (J. Sturhahn, pers. comm., Stock Assessment Division, Science Branch, Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, V9R 5K6). Mean lengths are available for lingcod caught in Johnstone Strait only. In 1999, the mean length of lingcod was 80.8 cm (stdev=12.66; n=118). Using research survey length and weight data in Cass et al. (1990, Appendix Table 7), a length-weight relationship for lingcod (1977-1985) is given by

$$\ln W_{kg} = 3.3287 * \ln(L_{cm}) - 12.94.$$

Applying 80.8 cm to this equation, the mean weight of a lingcod retained by the recreational fishery is approximately 5.4 kg. An estimate for the catch (tonnes) of lingcod in the recreational fishery in Area 4B is 30.5 tonnes. This represents a minimum estimate since the creel survey in Johnstone Strait does not cover the complete fishing season (May-October), though it is likely that the catch for the full season was less than 35 tonnes.

4.1.3 Climate-ocean regime considerations

The 1989 regime shift has been associated with changes in the Strait of Georgia ecosystem, most notably changes in Fraser River discharge (Beamish and McFarlane 1999). Corresponding shifts in dominant fish species have also been noted, and include increases in the abundance of Pacific hake and herring, along with substantial declines in coho marine survival. Some species such as Pacific cod, English sole and inshore rockfishes are at low abundance levels (Beamish and McFarlane 1999). Given observations regarding poor recruitment for many marine species during the 1989-1997 regime (McFarlane et al. 2000), rebuilding of the Strait of Georgia lingcod stocks during the 1990s might be expected to be slow.

4.1.4 Condition of the stock

While the recreational catch per record index indicates some improvement in lingcod abundance in recent years, recreational restrictions in salmon fishing may have limited the ability of this index to detect abundance trends. Given changes in the Strait of Georgia ecosystem that have been reported to coincide with the 1989 regime shift, lingcod might not have experienced strong year classes in the 1990s. Therefore, while the index has increased in recent years, abundance likely remains at levels which warrant conservation concern. There is no biological information to identify any current strong year classes, if present. However, in the upcoming spawning season, we plan to conduct nest density surveys. The results will be compared to similar surveys conducted in the late-1970s and early-1990s, in the hopes that these surveys will provide an additional, and independent, index of relative abundance.

4.1.5 Yield Options

The previous stock assessment for inshore lingcod (Beamish et al. 1995) recommended that the commercial fishery closure should be maintained and the current sport

fishing regulations should continue. Winter closure and size limit regulations should remain in place in the open portions of Management Areas 12 and 20.

Yield options remain unchanged from previous assessments.

5.0 OFFSHORE LINGCOD

5.1 Southwest Coast Vancouver Island (Area 3C)

5.1.1 Fishery and Management

Lingcod stocks off the southwest coast of Vancouver Island are exploited primarily by the trawl fishery, but also by hook and line and recreational fisheries. Since the 1940s, a size limit has been in place for all commercial fisheries. Initially, that limit was 58 cm (head-on) and the size was increased to 65 cm in 1996. In 1987, a winter closure (January 1 to April 30) was initiated for all commercial fisheries and in 1988 the period was extended to November 15 to April 15. In 1996, the winter closure for the trawl fishery was removed as a reflection of separate quota allocations for the trawl fishery and the hook and line fishery. The winter closure was initiated to protect males that guard nests and these were presumed to be unavailable to the trawl fishery since the males are typically on inshore reefs. In 1992, a winter closure (November 15-April 15) was initiated for the recreational fishery and a size limit of 65 cm was introduced in 1999. The first lingcod quota assigned to Area 3C was 1400 t in 1987 (B. Ackerman, pers. comm. Groundfish Unit, Fisheries Management Branch, Fisheries and Oceans Canada, 555 West Hastings Street, Vancouver, BC, V6B 5G3). The quota was increased to 2000 t in 1991, and 2100 t in 1993. The quota was reduced in 1996 to 1540 t and reduced again in 1997 to 1400 t of which 1225 t was allocated to the trawl fishery and 275 t to the line fishery. In 1998, the quota was further reduced to 950 t with 800 t allocated to the trawl fishery and 150 t to the line fishery.

For the 1999-2000 fishing year, a 65 cm size limit was in place for all lingcod retained in the commercial and recreational fisheries. The hook and line and recreational fisheries in Area 3C were subject to a winter closure from November 15 to April 15. The quota allocations remained at 800 t for the trawl fishery and 150 t for the hook and line fishery.

5.1.2 Catch Statistics

Since the 1950s, the trawl catch has accounted for the majority of lingcod landings in Area 3C (Table 2, Figure 3). American trawlers were active in Area 3C until the declaration of the Canadian Fishing Zone in 1977. However, US trawl catch was not recorded until 1954. During the 1950s and 1960s, the US trawl catch was at least equal to the Canadian trawl catch, but on average was 1.5 times larger. By the 1970s, the US trawl catch was approximately one third of the Canadian trawl catch and 1980 was the last year that American trawlers caught lingcod in Area 3C. The total trawl catch has varied between approximately 250 to 3400 t (Table 2). Line catch of lingcod dominated the total catch in Area 3C until the mid-1950s. The hook and line catch has been about one fifth that of the total trawl catch since the mid-1950s, and has varied from approximately 80 to 295 t (Table 2). Total catch of lingcod has ranged from 30 t to

3600 t (Table 2). Since the initiation of a quota in Area 3C in 1987, the total catch of lingcod has averaged approximately 62% of the total quota allocated for a fishing year.

Cass et al. (1988) outlined the selection of commercial catch data for compilation of catch per unit effort (CPUE) to use as lingcod abundance indices. Only landings of trawl vessels using double gear (i.e. gear suspended from a double cable) are used since they represent the majority of lingcod landings since the 1950s. Trawl catch records for 1954-1995 are from two sources (Rutherford 1999). Source 1 records, often designated "interviewed" records, consist of trip reports prepared by port liaison officers, based on fisher log books and supplemented by information obtained from observations during unloading of vessels, from sales slips, and from dockside monitoring records. Source 2 records are sales slips or landing records only and were not verified by a port observer. Both sources can provide estimates of total lingcod catch, but only the Source 1 records have associated effort data and are therefore suitable for use in constructing a CPUE index. Since 1996, Fisheries Observers have been on board all trawl vessels during fishing operations, and therefore all landings since 1996 are accompanied by a detailed trip report which includes effort data. Cass et al. (1990) suggested that only those landings which occurred during May-September should be used, as the trawl fishery is highly seasonal. Between 1954-1999, 84% of the Canadian lingcod catch occurred during May-September. Selecting landings from this time period also reduces any temporal bias introduced by the unavailability of male lingcod to the trawl fishery during the nesting season in October-April. In addition, they suggested that the most appropriate CPUE was based on the catch and effort from landings in which the lingcod catch accounted for 25% or more of the catch by weight (25% Qualified CPUE). Richards and Hand (1991) used a 25% CPUE index where effort was standardised for horsepower. However, Richards and Yamanaka (1992) examined differences between low and high horsepower CPUE indices and noted that they were similar since 1970. All subsequent lingcod stock assessments have used the 25% Qualified trawl CPUE (May-September) without standardised effort for horsepower as an indicator of lingcod abundance trends.

During the 1990s, total 3C trawl catch has declined from approximately 1200 tonnes in 1990-1991 to 250 t in 1999 (Table 2). The declining catch was accompanied by a declining 25% Qualified effort (Table 3, Figure 3). The 25% Qualified CPUE has also been decreasing in the 1990s, with two exceptions in 1993 and 1998. In 1993, there was an increase in trawl catch of lingcod, and a decline in the 25% Qualified effort. These were associated with a sharp increase in 25% Qualified CPUE (Figure 3). There was also an increase in 25% Qualified CPUE in 1998, but it was not accompanied by an increase in total trawl catch and may reflect high landings from a few fishing trips.

Recently, industry members have raised concern regarding the allocation of catch to statistical areas. We assign catch from any tow to a single statistical area based on the mid-point of the start and end points of the tow, even though the catch may occur at any point during the tow, and the tow may not be in a straight line. Industry members suggested that in Areas 3C and 3D, fishing tows are often started in one statistical area but end in the other, or start and end in one area, but "loop" into the other area for the majority of the tow. Analysis of individual tows conducted in 1996-1999 where the start or end point of the tow was in Area 3C indicates that between 0.1% and 16% of the total trawl catch assigned to Area 3C in these years was from tows that started in one area and ended in the other. Analysis of individual tows conducted in

1996-1999 where the mid-point of the tow was within 3 n.mi. of the border between Areas 3C and 3D indicated that between 1% and 7% of the total trawl catch assigned to Area 3C was from tows which may have "looped" into Area 3D. Both types of tows contributed to less than 1% of the 25% Qualified catch in either area for 1996-1999. Therefore, concern regarding allocation of catch to area is not likely paramount, and we continue to use the mid-point of trawl tows to designate lingcod catch to statistical area.

It is important to note that the proportion of the total trawl catch that qualified for the May through September level dropped substantially in 1996-1998. This does not reflect a decrease in the number of landings with 25% of the catch comprised of lingcod. Rather, it reflects a decrease in all catches of lingcod in May through September. As mentioned previously, the lingcod catch in May through September generally represents 84% of the total annual lingcod trawl catch. However, in 1996, 1997 and 1998, the lingcod catches in May through September were only 17%, 9% and 9% of the annual trawl catch for lingcod. In 1999, this proportion increased to 46%. The monthly lingcod catches for 1996-1998 were highest in December through February (Figure 4). For each of these time periods, the average number of trawl landings were 34 and the average landing of lingcod was 9.2 t, indicating winter catch was not limited to a few large landings. Biological samples (n=161) collected during winter months for these years were almost entirely female (99%). The dominant age of females (n=159) was 7 and the mean length was 80 cm. Sex ratio bias in catch can have implications on future recruitment. Trawl targeting on lingcod during winter months may have implications recruitment for the 1996-1998 year classes, since the catch was predominantly female.

The recreational fishery in and around Barkley Sound has been monitored by a creel survey program since 1984. Seasonal coverage of the creel survey has varied, with interviews conducted June through September in some years (1987, 1997, 1998 and 1999) and interviews conducted July through September since 1989. Only August and September have been continuously covered by the creel survey since 1984. Estimates of lingcod caught (kept and released) in August and September range from 259 pieces (in 1986) to 5849 pieces (in 1989) (Table 4).

Previous stock assessments have used the catch (kg) per unit effort (10 boat trips) as an index of abundance for lingcod around the Barkley Sound and Alberni inlet. These estimates were based on a mean weight of 1.6 kg. However, there are no biological data available for the recreational fishery to evaluate the appropriateness of this mean weight. Given an increase in the size limit, this mean weight is likely no longer applicable. We report on pieces per unit effort (10 boat trips) since it is not confounded with the difficulties of estimating mean weight (Table 4). The CPUE index has a high catch per unit effort in the late-1980s, lower rates from 1990-1995, and a return to higher rates in 1996, 1997 and 1998. The catch per unit effort in 1999 dropped drastically. This may reflect changes in angler behaviour given the restrictions to salmon fishing; however, it is important to note that fishing effort in 1999 remained high. The drastic drop in estimated lingcod catch more likely reflects the increase in legal size limit implemented in 1999.

5.1.3 Size and age composition of commercial landings

Biological sampling has been conducted on landed commercial catch from the lingcod trawl fishery in Area 3C since 1977. Samples provide data on length, sex, and where ageing structures are collected, age is determined by the fin-ray method (Chilton and Beamish 1982). In the early 1990s, age determination of lingcod was of questionable quality and it was determined that criteria used in the methodology had changed (McFarlane and Leaman 1993). As a consequence, several years of biological samples were re-estimated for individual ages using correct criteria. A number of additional samples collected between 1983 and 1988 have not yet been re-aged, and are therefore not included in this assessment. The fin-ray methodology for age determination of lingcod has since been validated (McFarlane and King 2000). For Area 3C, on average about 3 samples were collected each year ranging between 1 and 9. The average number of fish per sample was 280, with a range from 50 to 977. Ages are determined for all suitable samples, but for some large samples, age determination is done for a random subsample of age structures.

Catch curves for combined age frequency data for 1977-1999 illustrate that lingcod begin to recruit at age 2 (Figure 5). Full recruitment for males is at age 5, while that for females is at age 6 (Figure 5). We therefore use relative high proportions of age 4 lingcod to identify potential strong year classes. Annual age composition was plotted as an age proportion bubble plot (Figure 6). The plot was created using S-Plus code (Mathsoft 2000) provided by R. Haigh (Pers. Comm., Stock Assessment Division, Science Branch, Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, V9R 5K6). The 1985 year class ins the most dominant year class evident in the bubble plot (Figure 6). The year class first appeared as 4 year olds in the 1989 fishery, followed through as 5, 6, 7 and 8 year olds in the 1990-1993 fisheries. In addition, the 1989-1991 year classes also appeared to be of moderate strength, though sample sizes in the 1993, 1994 and 1996 fisheries were small (n=100, 50 and 63) and might not be sufficient to represent the relative proportion of these year classes.

An increase in mean size (cm) for males accompanied the increase in the size limit that occurred in 1996 (Figure 7). There was no evidence of a long-term trend in size for either sex prior to 1996.

5.1.4 Climate-Ocean Regime Considerations

Many groundfish species exhibited above average year class strength during the 1977-1988 regime (McFarlane et al. 2000). Lingcod year classes appeared to be of at least moderate strength during this period. Several aspects of the west coast Vancouver Island ecosystem changed with the 1989 regime shift, and include zooplankton composition, upwelling and downwelling intensity (King et al. 2000b). King et al. (2000a) noted that sablefish year class strength declined abruptly after the 1989 regime shift. McFarlane et al. (2000) noted that several groundfish species exhibited below average year class strength after 1989. Lingcod year classes do not appear to be strong or persistent in the fishery after 1989 (Figure 6).

5.1.5 Condition of the stock

The 25 % Qualified CPUE has remained at a consistent level during the late 1990s. The 25% Qualified CPUE did increase dramatically in 1998, though this was accompanied by a low level of effort. The recreational fishery catch per unit effort (pieces/hour) also increased in 1998. However, both commercial 25% Qualified CPUE and recreational CPUE decreased in 1999. At present there does not appear to be any indication of large, persistent changes in lingcod abundance in Area 3C. Age composition data indicate the 1985 year class was strong and supported the fishery into the early 1990s. However, there is no indication that other year classes have been as strong in the 1990s. The switch in fishery behaviour in 1996-1998 noted above may negatively impact recruitment of the 2001-2003 fisheries and should be monitored in future stock assessments.

5.1.6 Yield Recommendations

The current quota of 950 tonnes was initiated in 1998 (Appendix II Table A4). The previous stock assessment (Leaman and McFarlane 1997) recommended that the total removals not exceed the 1000 t level. In addition, they recommended a conservative harvesting approach until there is indication that the stock has initiated either a very strong cohort or a series of stronger cohorts.

We have no new information to alter previous advice. We therefore recommend that the total removals do not exceed 1000 t. All existing commercial and recreational fishing regulations should remain in place.

5.2 Northwest Coast Vancouver Island (Area 3D)

5.2.1 Fishery and Management

Lingcod off the northwest coast of Vancouver Island (Area 3D, Figure 2) are exploited primarily by the trawl fishery, but also by the hook and line and recreational fisheries. As early as the 1940s, a size limit of 58 cm (head-on) was applied to all commercial lingcod fisheries. In 1987, a winter closure (Jan. 1 – April 30) was applied to the commercial fishery in order to protect spawning fish and nest guarding males. The following year this closure was extended to Nov. 15 – April 15. In 1992, a similar winter closure was implemented for the recreational fishery in Area 3D (W. Grider, pers. comm.). A quota of 600 t was implemented for Area 3D in 1993, and applied to both the trawl and hook and line fisheries (B. Ackerman, pers. comm.). In 1996 the 58 cm commercial size limit was increased to 65 cm (head-on), and the combined trawl and line quota was increased to 660 t (B. Ackerman, pers. comm.). In addition, the trawl fishery for lingcod in Area 3D was affected by the same management changes in 1996 as noted for Area 3C, regarding quarterly trip limits, observers, and bycatch reduction measures and the removal of a winter closure. In 1997, the quota was reduced to 400 t, of which 220 t was allocated to the trawl fishery, and 180 t was allocated to the hook and line fishery (B. Ackerman, pers. comm.). In 1999, a size limit of 65 cm (head-on) was applied to the recreational fishery in Area 3D for the first time.

For the 1999-2000 fishing year, a 65 cm (head-on) size limit was in place for all lingcod retained in the commercial and recreational fisheries. Winter closures applied to the commercial hook and line and recreational fisheries from Nov. 15 – April 15. Quotas of 220 t and 180 t were allocated to trawl and hook and line fisheries, respectively. A daily limit of 3 pieces applied to the recreational fishery.

5.2.2 Catch Statistics

Commercial catch statistics, including 25% Qualified catch, effort, and catch per unit effort (CPUE) for Area 3D were compiled in the same manner as for Area 3C (Table 5 and Table 6). Total catch in Area 3D has ranged from less than 100 t in the 1920s-1940s to a high of 1400 t in 1994 (Table 5, Figure 3). Catches were largely dominated by the trawl fishery from about 1961 – 1996, but in recent years (1997-1998) line catches have exceeded trawl catches.

American trawlers were active in Area 3D until the declaration of the Canadian Fishing Zone in 1977. However, US trawl catch was not recorded until 1954. During 1954-1963, total trawl catch averaged 137 tonnes per year, of which about 60% was caught by US trawlers (Table 5). In 1964-1972, Canadian trawl catch increased dramatically, due to dramatic increase in effort (Table 6 , Figure 3). Total catch peaked at 976 t in 1968, of which 719 t was caught by Canadian trawlers. US trawl catch remained at similar levels to the previous decade, but now averaged only 17% of the total trawl catch. Between 1973 and 1977, total trawl catch was around 233 tonnes per year, with Canadian and US trawlers each contributing about 50% of the total catch. The last recorded catch by US trawlers in Area 3D was in 1981.

The 25% Qualified catch has typically represented about 70% of the total trawl landings. However, in the 1990s, this proportion dropped to approximately 40%. The 25% Qualified catch and effort peaked in 1994 at 581 t and 2033 h, contributing significantly to the historic high of 1400 t total catch (Table 5 and Table 6, Figure 3). However, the 25% Qualified CPUE was 286 kg/h in 1994, approximately equal to the long term (1954-1999) median CPUE of 291 kg/h. The 25% Qualified catch, effort, and CPUE declined substantially in 1995, although levels were quite similar to those in the early 1990s, and may reflect that effort levels in 1994 were unusually high. Significant management changes introduced in 1996 have changed the behaviour of the trawl fleet, and may have resulted in reduced targeting on lingcod. As a result, 25% Qualified catch and effort have declined sharply, and in 1997-1999 ranged from 16 – 34 t, and from 64 – 108 h, respectively. Total trawl catch in these years ranged from 83-106 t. The 25% Qualified CPUE was 263 kg/h in 1997, but increased to over 300 kg/h in 1998 and 1999.

The proportion of the interviewed trawl catch that meets qualification levels is the lowest in the time series for the period 1997-1999. This is due largely to a dramatic drop in May-September trawl catch (Figure 4). However, unlike Area 3C, this change in summer lingcod landings was not accompanied by a large increase in winter landings (Figure 4).

Line catch of lingcod in Area 3D began increasing in 1985, rising from 194 t in 1985 to 673 t in 1993, but dropping to 182 t by 1996 (Table 5, Figure 3). Over this time period, line catch accounted for an average of around 45% of the total catch in Area 3D. In 1997, 1998, and 1999 line catch increased to 230, 258 and 206 t respectively, accounting for around 67% of the total catch. Most of the lingcod caught by hook and line in Area 3D is incidental to the

rockfish hook and line fishery, but recent increases in line catches are due to increased targeting on lingcod (Leaman and McFarlane 1997). The substantial reduction in effort in the trawl fishery may have resulted in increased opportunities for hook and line vessels to target lingcod.

5.2.3 Size and age composition of commercial landings

Biological sampling has been conducted on landed commercial catch from the lingcod trawl fishery in Area 3D since 1979. One to three samples were collected intermittently from 1979-1999. The average number of fish per sample was 100, with a range from 50 to 210. Ages are usually determined for a proportion of the suitable samples, as time and budgetary constraints permit.

Catch curves from combined age frequency data for 1979-1999 are much noisier than those for Areas 3C and 5A/B, most likely due to the limited number of years for which samples are available, and may not reflect the overall catch composition. However, it is most likely that the catch composition for Area 3D is similar to Areas 3C and 5A/B, and that the age of full recruitment is around age 5. The age composition structure available from bubble plots (Figure 6), can not be interpreted for strong and persistent year classes in the fishery since many consecutive years are missing.

There was no detectable increase in the mean size of males or females after the size limit increase in 1996 (Figure 7).

5.2.4 Climate-Ocean Regime Considerations

Many groundfish species exhibited above average year class strength during the 1977-1988 regime (McFarlane et al. 2000). Several aspects of the west coast Vancouver Island ecosystem changed with the 1989 regime shift, and include zooplankton composition, upwelling and downwelling intensity (King et al. 2000b). King et al. (2000a) noted that sablefish year class strength declined abruptly after the 1989 regime shift. McFarlane et al. (2000) noted that several groundfish species exhibited below average year class strength after 1989. While lingcod year class strength information is not available for Area 3D, it is likely that year classes in the 1990s were not strong.

5.2.5 Condition of the stock

Stock abundance in Area 3D shows no evidence of a decline based on the 25% Qualified CPUE for recent years. However, we caution that the changes in management which occurred in 1996 have significantly changed the lingcod fishery, resulting in substantially reduced effort in the trawl fishery, accompanied by a rise in targeted effort in the hook and line fishery, thereby eroding the reliability of the 25% Qualified trawl CPUE as a relative abundance index for this area. In addition, we have little biological information with which to assess year class strength.

5.2.6 Yield recommendations

Recommended low to high risk sustainable yield options were set to 400-800 t in Area 3D in the 1991 stock assessment (Appendix II Table A4; Richards and Yamanaka, 1992). These yield options were based on an estimated sustainable yield of 600 t, determined from the mean of the group of historical catches that were greater than the long term mean of 400 t (Richards and Hand, 1991). The previous stock assessment (Leaman and McFarlane 1997) did not recommend changes to the existing quota recommendations. However they did recommend that managers consider a low risk approach to harvest for this stock.

We have no new information to revise the existing quota recommendation. We recommend the continuation of existing commercial and recreational regulations.

5.3 Queen Charlotte Sound (Areas 5A and 5B)

5.3.1 Fishery and Management

Lingcod stocks in Queen Charlotte Sound (Areas 5A and 5B, Figure 2) are primarily exploited by the trawl fishery, although lingcod is a minor component of the total trawl fishery. There are also small catches by the hook and line fishery.

A size limit of 58 cm (head-on) originally applied to these areas, but was increased to 65 cm (head-on) in 1996. In 1987, a winter closure of January 1 to April 15 was initiated for all commercial fisheries in portions of Area 5A. This period was extended to November 15 to April 30 in 1988. The trawl winter closure was removed in 1996. In 1999, a specific winter closure was not specified for the line fishery in Area 5A, rather the fishery was opened from April 15 until the total allowable catch was obtained. A quota of 1650 t was implemented in 1993 and applied to both the trawl and the hook and line fisheries. The combined quota was increased to 1815 t in 1996. In 1997, the quota was reduced to 1100 t, of which 862 t and 238 t were allocated to the trawl and hook and line fisheries, respectively. In 1998, the allocations were changed slightly, to 900 t and 200 t, respectively. In 1999, the trawl quota was reduced to 862 t, but the hook and line allocation specified 125 t for Area 5A and 75 t for Area 5B (200 t in total). The trawl fishery for lingcod in Areas 5A and 5B was affected by the same management changes in 1996 as noted for Area 3C, regarding quarterly trip limits, observers, and bycatch reduction measures.

For the 1999-2000 fishing year, a 65 cm (head-on) size limit was in place for all lingcod retained in the commercial fisheries. There was no size limit for lingcod retained in the recreational fishery. The quota allocations remained at 862 t for the trawl fishery in Areas 5A and 5B combined, and 125 t and 75 t for the hook and line fishery in Area 5A and Area 5B, respectively. A daily limit of 3 pieces applied to the recreational fishery.

5.3.2 Catch Statistics

Commercial catch statistics, including 25% Qualified catch, effort, and catch per unit effort (CPUE) for Areas 5A and 5B were compiled in the same manner as for Area 3C (Table 7 and Table 8). Total catch has ranged from less than 100 t prior to the 1940s, to historic

highs of around 2300 t in 1968 and 1990 (Table 7, Figure 3). Catches have been dominated by the trawl fishery since the 1950s. American trawlers were active in Areas 5A and 5B until the declaration of the Canadian Fishing Zone in 1977. However, US trawl catch was not recorded until 1954. US trawl catch averaged around 60% of the total trawl catch for the duration of the US fishery in Queen Charlotte Sound (Table 7). The last recorded catch by US trawlers in Areas 5A and 5B was in 1980. Hook and line catch has increased since 1987, rising to a high of 305 t in 1991, and falling to 262 t in 1992 (Table 7, Figure 3). Line catches in 1993-1999 have averaged about 154 t/year.

The 25% Qualified catch has historically represented about 65% of the total trawl catch. There have not been any recent declines in this proportion in recent years as were observed in other areas. The 25% Qualified effort increased dramatically from an average of around 700 h in the 1970s to 2039 h in 1981 (Table 8, Figure 3). The 25% Qualified effort averaged around 3100 h in 1981-1995. In contrast, the 25% Qualified CPUE peaked in 1986 at 433 kg/h, and has declined steadily. In 1995, CPUE was only 168 kg/h, much smaller than the long term (1951-1999) median and average of 245 kg/h and 249 kg/h, and one of the smallest CPUE values in the time series. Following the management changes in 1996, total trawl catch decreased by about 50% from 1239 – 633 t, while the 25% Qualified effort decreased by about 60% from 5412 – 2362 h. At the same time, CPUE increased from 168 – 196 kg/h. In 1997, catch and effort again declined, but CPUE increased to 217 kg/h. Since 1997, total trawl catch has risen from 386 – 533 t, and effort from 1082 – 2167 h, while CPUE has declined from 217 – 173 kg/h.

5.3.3 Size and age composition of commercial landings

Biological sampling has been conducted on landed commercial catch from the lingcod trawl fishery in Areas 5A and 5B since 1977. On average, about 3 samples per year are collected, although the number of samples ranges between 1 and 6. The average number of fish per sample was 168, with a range from 50 to 382. Ages are usually determined for a proportion of the suitable samples, as time and budgetary constraints permit. As for Area 3C, ages were estimated during the early 1990's using incorrect aging criteria. Of the affected samples, only those where ages have been re-estimated using correct criteria have been included in this assessment. A number of samples which were collected between 1981 and 1990 have yet to be re-aged and are therefore not included. As for Area 3C, some large samples are subsampled prior to age determination.

Catch curves from combined age frequency data (1977-1999) reveal that the age of full recruitment for males is 5 and that for females is 6 (Figure 5). The 1985 year class appears as a dominant and persistent year class in the fishery from 1989-1993, as ages 4-8 (Figure 6). The year classes 1976-1978 appear to be of comparable strength to the 1985 year class in the few years where samples are available (1981 and 1983), but due to the lack of samples in subsequent years it is impossible to evaluate the persistence of these year classes. As with Area 3C, the 1990 and 1991 year classes appeared in the 1994 and 1995 fisheries as moderate proportions at age 4. However, these year classes did not appear to dominant the fishery in subsequent years. The 1993 year class was prominent in the 1997 fishery sample as 4 year olds, though the sample size is probably too small (n=50) to be representative of relative proportions-at-age. In addition, the 1994 year class was prominent in the 1999 fishery sample (n=250) as 5 year olds.

There was no change in the mean size of males or females following the increase in size limit in 1996 (Figure 7). In fact, the mean size of males in 1996 was below the size limit of 65 cm.

5.3.4 Climate-ocean regime considerations

At present, we do not have ecosystem information for Queen Charlotte Sound. The regime shifts of 1977 and 1989 that produced abrupt changes in the Strait of Georgia and the west coast Vancouver Island ecosystems will have also had consequences for the Queen Charlotte Sound ecosystem, since those regime shifts were observed in basin-wide north Pacific climate-ocean systems.

5.3.5 Condition of the stock

Though the 25% Qualified CPUE for lingcod stocks in Areas 5A and 5B has been declining since the late 1980s, it has remained fairly constant since 1992. There is some indication that the 1993 year class was of at least moderate strength.

5.3.6 Yield recommendations

Recommended low to high risk yield options have been suggested as 1100-2200 t in Areas 5A/5B (Appendix II Table A4; Richards and Yamanaka, 1992). These yield options were based on equilibrium fishing model analyses (Schnute et al. 1989) and consideration of the productivity off the west coast of Vancouver Island. However, model results should be considered with some caution, as the growth and mortality estimates used were not well defined (Richards and Yamanaka 1992), and examination of the ageing data created additional uncertainty (McFarlane and Leaman, 1995). Quotas were set 1100 t in 1996, and have remained at that level.

The previous stock assessment (Leaman and McFarlane 1997) recommended low and high risk yield options of 1100 and 2200 t. However, they recommended the low risk approach to harvest for this stock.

We have no new information to revise the existing quota recommendation. We recommend the continuation of existing commercial and recreational regulations.

5.4 Hecate Strait (Areas 5C and 5D) and West Coast Queen Charlotte Islands (Area 5E)

5.4.1 Fishery and Management

Lingcod in Hecate Strait (Areas 5C and 5D, Figure 2) and off the west coast of the Queen Charlotte Islands (Area 5E, Figure 2) are a minor component of both the trawl and hook and line fishery. However, hook and line landings have accounted for an increasing proportion of the total catch, and in recent years, the directed line fishery for lingcod has also increased.

A size limit of 58 cm (head-on) originally applied to these areas, but was increased to 65 cm (head-on) in 1996. No winter closures have been applied to date. A quota of 1000 t was implemented in 1993 and applied to both the trawl and hook and line fisheries in

Areas 5C and 5D. The combined quota was increased to 1100 t in 1996. In 1997, the quota coverage was extended to include Area 5E. The total quota was 1000 t, of which 580 t and 420 t applied to the trawl and hook and line fisheries, respectively. The trawl fishery for lingcod in Areas 5C, 5D, and 5E was affected by the same management changes in 1996 as noted for Area 3C, regarding quarterly trip limits, observers, and bycatch reduction measures.

For the 1999-2000 fishing year, a 65 cm (head-on) size limit was in place for all lingcod retained in the commercial fisheries. There was no size limit for lingcod retained in the recreational fishery. The quota allocations remained at 580 t for the trawl fishery, and 420 t for the hook and line fishery. A daily limit of 3 pieces applied to the recreational fishery.

5.4.2 Catch Statistics

Commercial catch statistics, including 25% Qualified catch, effort, and catch per unit effort (CPUE) for Areas 5C, 5D, and 5E were compiled in the same manner as for Area 3C (Table 9, Table 10, Table 11 and Table 12). Total catch in Areas 5C and 5D have ranged from less than 100 t prior to the 1940s to historic highs of around 750 – 850 t in 1991 – 1995 (Table 9, Figure 3). Catches have historically been dominated by the trawl fishery, but line catches have exceeded trawl catches since 1998. Catches in Area 5E have ranged from less than 20 t / year prior to 1976, to a historic high of 216 t in 1999, and have been dominated by the hook and line fishery since the earliest recorded statistics in 5E in 1951 (Table 11, Figure 3).

American trawlers were active in Areas 5C and 5D until the declaration of the Canadian Fishing Zone in 1977. However, US trawl catch was not recorded until 1954. US trawl catch initially accounted for a high proportion of the total trawl catch (80%), but the proportion fell steadily, and by 1963, US catch accounted for less than 20% of the total trawl catch (Table 9). From 1972 until 1982, US trawl catch averaged less than 1 t / year. No US catch has been recorded in Area 5E.

Total trawl catch and 25% Qualified effort in Areas 5C and 5D began increasing in the early 1960s, and reached a high of 459 t and 531 h in 1971 (Table 10, Figure 3). Both catch and effort fell during the 1970s, but began to rise again in the early 1980s. Trawl catch reached historic highs of 750 – 850 t in 1991 – 1995, while effort peaked at 594 t and 679 t in 1991 and 1995, respectively. As in other areas of the coast, catch and effort dropped substantially after the introduction of new management measures in 1996. Trawl catch was only 67 t in both 1998 and 1999, while 25% Qualified effort was 117 and 76 h, respectively.

CPUE appears to have generally declined, with high peak values (800-900 kg/h) occurring in 1951-1965, a lower peak of 611 kg/h in 1975, and peaks of 413 and 495 kg/h in 1987 and 1994, respectively. CPUE in 1997-1998 was 176 and 113 kg/h, respectively, lower than the long term (1954-1999) median of 269 kg/h, while CPUE in 1999 was 260 kg/h, and quite similar to the long term median. In general, CPUE has been quite erratic over the time series, and Leaman and McFarlane (1997) suggest that the low level of the 25% Qualified effort renders the CPUE time series of questionable value.

Line catch in Areas 5C and 5D was small (< 150 t) prior to the mid 1980s, but has accounted for an increasing proportion of the total catch in subsequent years and now represents

approximately half of the landings in the 1990s (Table 9, Figure 3). Lingcod has traditionally been incidental to the halibut and rockfish line fisheries, but in recent years, targeting on lingcod has increased (Leaman and McFarlane 1997).

Catches in Area 5E were exclusively from the hook and line fishery from 1951 – 1975, and totaled less than 20 t / year during this period (Table 11, Figure 3). Line catch has risen steadily since the mid 1980s, and has averaged about 120 t/year through the 1990s. In 1999, line catch reached a historic high of 216 t. As with Areas 5C and 5D, directed fishing for lingcod has increased in Area 5E, and may be responsible for the increase in 1999. Trawl catch from 1976-1999 was less than 30 t/year and accounted for about 16% of the total catch on average. Very few years had sufficient catch to meet 25% qualification levels (Table 12).

5.4.3 Size and age composition of commercial landings

There are a limited number of biological samples for Areas 5C/D and only 1 in 1997 (n=50) for Area 5E. Age samples for Areas 5C/D were available only for 1977, 1994, 1995 and 1997 (Figure 6). Only 1 or 2 samples were collected in each of these years. The average number of fish per sample was 93, ranging from 53 to 121. Length samples were available only for 1991, 1994-1996 and 1999-2000. The limited length information suggests that the mean size of males increased slightly after the size limit change in 1996, while the size of females did not change (Figure 7).

5.4.4 Climate-ocean regime considerations

At present, we do not have ecosystem information for Hecate Strait and west coast of the Queen Charlotte Islands. The regime shifts of 1977 and 1989 that produced abrupt changes in the Strait of Georgia and the west coast Vancouver Island ecosystems will have also had consequences for these areas, since those regime shifts were observed in basin-wide north Pacific climate-ocean systems. McFarlane et al. (2000) did note that several groundfish species in Hecate Strait exhibited above average year classes in the 1977 to 1988 regime, and below average year classes since 1989.

5.4.5 Condition of the stock

Based on the lack of a trend in the 5C/D CPUE index in recent years, there is no evidence that this stock is over exploited. However, caution is advised, as historic trawl effort levels in 5C/D may be too low to provide a reliable CPUE index. In addition, there is no CPUE index available in 5E, and the rapidly expanding line fishery can provide little information about current stock status in this area. It is noted that several groundfish species in Hecate Strait have exhibited below average year classes since the 1989 regime shift.

5.4.6 Yield recommendations

A precautionary yield level of 1000 t was recommended for Areas 5C/D and 5E combined in 1997 (Appendix II Table A4; Leaman and McFarlane), and has remained at that level for subsequent years. We have no new information to revise the existing yield level, but recommend that managers adopt a conservative approach in consideration of the unreliable nature

of the CPUE index in 5C/D, and the rapidly expanding line fishery coupled with a lack of any relative abundance index in 5E. Given the ongoing expansion of the line effort in all areas, we recommend consideration of a winter closure similar to existing closures in other areas.

6.0 REFERENCES

Beamish, R.J. and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50: 1002-1016.

Beamish, R.J. and G.A. McFarlane. 1999. Applying ecosystem management to fisheries in the Strait of Georgia. pp. 637-664. *In* Ecosystem Approaches for Fisheries Management. Alaska Sea Grant College Program. AK-SG-99-01.

Beamish, R.J., G.A. McFarlane and J.R. King. 2000. Fisheries climatology: understanding decadal scale processes that naturally regulate British Columbia fish populations. pp. 94-193. *In* Fisheries Oceanography: An Integrative Approach to Fisheries Ecology and Management. P. Harrison and T. Parsons [eds.]. London, Blackwell Science.

Beamish, R.J., D. Noakes, G.A., McFarlane, L. Klayshtorin, V.V. Ivanov and V. Kurashov. 1999. The regime concept and natural trends in the production of Pacific salmon. Can. J. Fish. Aquat. Sci. 56: 516-526.

Beamish, R.J., B.L. Thomson and C.M. Neville. 1995. Inshore Lingcod. Pp. 25-40. *In* Groundfish Stock Assessments for the West Coast of Canada in 1994 and Recommended Yield Options for 1995. M. Stocker and J. Fargo [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

Cass, A.J., L.J. Richards and J.T. Schnute. 1988. A Summary of Fishery and Biological Data for Lingcod off the Southwest Coast of Vancouver Island. Can. Tech. Rep. Fish. Aquat. Sci. 1618: 33 p.

Cass, A.J., R.J. Beamish and G.A. McFarlane. 1990. Lingcod (*Ophiodon elongatus*). Can. Spec. Pub. Fish. Aquat. Sci. 109: 40 p.

Chilton, D.E. and R.J. Beamish. 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60: 102 p.

Clark, W.G., S.R. Hare, A.M. Parma, P.J. Sullivan, R.J. Trumble. 1999. Decadal changes in growth and recruitment of Pacific halibut (*Hippoglossus stenolepis*). Can. J. Fish. Aquat. Sci. 56: 242-252.

Department of Fisheries of Canada. 1951-1968. British Columbia Catch Statistics by area and type of gear (as reported on sales slips received by the department) [1951-1968]. Department of Fisheries Canada, Pacific Area. 18 v.

Department of Fisheries and Forestry of Canada. 1969-1971. British Columbia Catch Statistics by area and type of gear (as reported on sales slips received by the department) [1969-1971]. Department of Fisheries and Forestry of Canada, Fisheries Service, Pacific Region. 3 v.

Department of the Environment. 1972-1975. British Columbia Catch Statistics by area and type of gear (as reported on sales slips received by the department) [1972-1975]. Department of the Environment, Fisheries and Marine Service, Pacific Region. 4 v.

Department of the Environment. 1976-1977. British Columbia Catch Statistics by area and type of gear (as reported on sales slips received by the department) [1976-1977]. Department of the Environment, Fisheries Management, Pacific Region. 2 v.

Dominion Bureau of Statistics, Fisheries Div. 1922-1949. Fisheries Statistics of Canada [1920-1946]. Ottawa, King's Printer, 27 v.

Ebbesmeyer, C.C., D.R. Cayan, D.R. McLain, F.H. Nichols, D.H. Peterson and K.T. Redmond. 1991. 1976 step in the Pacific climate: Forty environmental changes between 1968-1975 and 1977-1984. pp. 115-126. *In* Proceedings of the Seventh Annual Pacific Climate (PACLIM) Workshop, Asilomar, California, April 1990. J.L. Betancourt and V.L. Tharp [eds.]. Calif. Dep. Water Resour. Interagency Ecol. Stud. Program. Rep. No. 26.

Forrester, C.R. 1973. The lingcod (*Ophiodon elongatus*) in waters off western Canada. Fish. Res. Bd. Can. MS Rep. 1266: 27 p.

Fisheries and Oceans. 1978-1984. British Columbia Catch Statistics by area and type of gear (as reported on sales slips received by the department) [1978-1984]. Fisheries and Oceans, Fisheries Management, Pacific Region. 7 v.

Fisheries and Oceans Canada. 1985-1993. British Columbia Commercial Catch Statistics by species, gear, month, and area [1985-1993]. Fisheries and Oceans Canada, Pacific Region. 9 v.

Francis, R.C. and S.R. Hare. 1994. Decadal-scale regime shifts in the large marine ecosystems of the North-east Pacific: a case for historical science. Fish. Oceanogr. 3: 279-291.

Haist, V. 1995. Lingcod abundance indices. pp. 52-68. *In* Groundfish Stock Assessments for the West Coast of Canada in 1994 and Recommended Yield Options for 1995. M. Stocker and J. Fargo [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

Hare, S.R. and R.C. Francis. 1995. Climate change and salmon production in the northeast Pacific Ocean. pP. 357-372. *In* Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Hare, S.R. and N.J. Mantua. 2000. On the assessment and identification of recent North Pacific climate regime shifts. Prog. Oceanogr. *In press.*

Kawasaki, T. and M. Omori. 1988. Fluctuations in the three major sardine stocks in the Pacific and the global temperature. pp. 37-53. *In* Long Term Changes in Marine Fish Populations. A Symposium held in Vigo, Spain, November 18-21, 1986. T. Wyatt and M.G. Larrañeta [eds.].

Ketchen, K.S. 1976. Catch and effort statistics of the Canadian and United States trawl fisheries in waters adjacent to the British Columbia coast. 1950-1975. Fish. Mar. Serv. Data Rep. 6:578p.

Ketchen, K.S., N. Bourne and T.H. Butler. 1983. History and present status of fisheries for marine fishes and invertebrates in the Strait of Georgia, British Columbia. Can. J. Fish. Aquat. Sci. 40: 1095-1117.

King, J.R., V.V. Ivanov, V. Kurashov, R.J. Beamish and G.A. McFarlane. 1998. General circulation of the atmosphere over the North Pacific and its relationship to the Aleutian Low. North Pacific Anadromous Fish Commission Document, No. 318.

King, J.R., G.A. McFarlane and R.J. Beamish. 2000a. Decadal scale patterns in the relative year class success of sablefish, *Anoplopoma fimbria*. Fish. Oceangr. 9: 62-70.

King, J.R., G.A. McFarlane and R.J. Beamish. 2000b. Incorporating the dynamics of marine systems into the stock assessment and management of sablefish. Prog. Oceanogr. *In press*.

Leaman, B.M. and G.A. McFarlane. 1997. Offshore Lingcod Stock Assessment and Recommended Yield Options for 1998. Can. St. Assess. Sec. Res. Doc. 97/131.

Low, C.J. and R.J. Beamish. 1978. A study of the nesting behaviour of lingcod (*Ophiodon elongatus*) in the Strait of Georgia, British Columbia. Fish. Mar. Serv. Tech. Rep. 843: 27 p.

Mackas, D.L. 1995. Interannual variability of the zooplankton community off southern Vancouver Island. pp. 603-615. *In* Climate Change and Northern Fish Populations. R.J. Beamish [ed.]. Can. Spec. Pub. Fish. Aquat. Sci. 121.

Mackas, D.L., R.E. Thomson, M. Galbraith and R.I. Perry. 1999. Changes in the N.E. Pacific continental margin zooplankton community 1985-1998. Eighth Annual Meeting of the North Pacific Marine Science Organization, October 8-17, 1999, Vladivostok, Russia, abstract.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bull. Am. Met. Soc. 78: 1069-1079.

Mathsoft. 2000. S-Plus 2000, Modern Statistics and Advanced Graphics. Data Analysis Product Division, Mathsoft, Seattle, WA.

McFarlane, G.A. and J.R. King. 2000. The validity of the fin-ray method of age determination for lingcod (*Ophiodon elongatus*). Fish. Bio. *In press*.

McFarlane, G.A. and B.M. Leaman. 1993. Offshore lingcod. pp. 33-48 *In* Groundfish Stock Assessments for the West Coast of Canada in 1992 and Recommended Yield Options for 1993. B.M. Leaman and M. Stocker [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 1919: 407 p.

McFarlane, G.A. and B.M. Leaman. 1995. Offshore lingcod. pp. 97-114 *In* Groundfish Stock Assessments for the West Coast of Canada in 1992 and Recommended Yield Options for 1993. M. Stocker & J. Fargo [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

McFarlane, G.A., J.R. King and R.J. Beamish. 2000. Have there been recent changes in climate? Ask the fish. Prog. Oceanogr. *In press*.

Minobe, S. 1997. A 50-70 year climatic oscillation over the North Pacific and North America. Geophy. Res. Lett. 24: 683-686.

Overland, J.E., J.M. Adams and N.A. Bond. 1999. Decadal variability of the Aleutian Low and its relation to high latitude circulation. J. Climate 12: 1542-1548.

Phillips, A.C. and W.E. Barraclough. 1977. On the early life history of the lingcod (*Ophiodon elongatus*). Fish. Mar. Serv. Tech. Rep. 756: 35 p.

Polovina, J.J. 1996. Decadal variation in the trans-Pacific migration of northern bluefin tuna (*Thunnus thynnus*) coherent with climate-induced change in prey abundance. Fish. Oceanogr. 4: 114-119.

Polovina, J.J., G.T. Mitchell, N.E. Graham, M.P. Craig, E.E. Demartini and E.N. Flint. 1994. Physical and biological consequences of a climate event in the central North Pacific. Fish. Oceanogr. 3: 15-21.

Richards, L.J. and C.M. Hand. 1991. Lingcod. Pp. 19-42, *In* Groundfish Stock Assessments for the West Coast of Canada in 1990 and Recommended Yield Options for 1991. J. Fargo and B.M. Leaman [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 1778.

Richards, L.J. and K.L. Yamanaka. 1992. Lingcod. Pp. 23-55, *In* Groundfish Stock Assessment for the West Coast of Canada in 1991 and Recommended Yield Options for 1992. B.M. Leaman [ed.]. Can. Tech. Rep. Fish. Aquat. Sci. 1866.

Rutherford, K.L. 1999. A brief history of GFCATCH (1954-1995), the Groundfish Catch and Effort Database at the Pacific Biological Station. Can. Tech. Rep. Fish. Aquat. Sci. 2299:66 p.

Schnute, J.T., L.J. Richards, and A.J. Cass. 1989. Fish survival and recruitment: investigations based on a size-structured model. Can. J. Fish. Aquat. Sci. 46: 743-769.

Rutherford, K.L. 1999. A brief history of GFCATCH (1954-1995), the groundfish catch and effort database at the Pacific Biological Station. Can. Tech. Rep. Fish. Aquat. Sci. 2299: 66 p.

Thomson, J.A. and A.N. Yates. 1960. British Columbia landings of trawl-caught groundfish by month, by major statistical area. Fish. Res. Board. Can. Circ. (Statistical Series) No. 1.

Thomson, J.A. and A.N. Yates. 1961a. British Columbia landings of trawl-caught groundfish by month, by major statistical area. Fish. Res. Board. Can. Circ. (Statistical Series) No. 2.

Thomson, J.A. and A.N. Yates. 1961b. British Columbia landings of trawl-caught groundfish by month, by major statistical area. Fish. Res. Board. Can. Circ. (Statistical Series) No. 3.

Waddell, B.J. and D.M. Ware. 1995. Historic domestic and foreign fish catch statistics for British Columbia: 1920-1991. Can. Tech. Rep. Fish. Aquat. Sci. 2030: 37 p.

Watanabe, M. and T. Nitta. 1999. Decadal changes in the atmospheric circulation and associated surface climate variations in the Northern Hemisphere winter. J. Climate 12: 494-510.

Wilby, G.V. 1937. The lingcod, *Ophiodon elongatus* Girard. Bull. Fish. Res. Board Can. 54: 24 p.

Table 1. Summary of Strait of Georgia creel survey data for 1984-1999 for all interviews, and interviews with no directed lingcod effort.

	All interviews				Interviews without lingcod effort	
		Number of lingcod				
Year	Number	Kept	Released	Total	Number	Catch per record
1984	26118	4558	2404	6992	25465	0.212
1985	33165	3601	1435	5036	32645	0.125
1986	29129	3392	1350	4742	28734	0.135
1987	30393	3132	1405	4537	29827	0.118
1988	27436	2693	755	3448	26954	0.088
1989	24763	1860	847	2707	24501	0.093
1990	25088	1150	1709	2859	24881	0.095
1991	21882	326	2934	3260	21832	0.145
1992	29389	303	4612	4915	29336	0.162
1993	24590	238	2685	2923	24531	0.115
1994	19859	203	2144	2347	19789	0.119
1995	15579	182	1337	1519	15499	0.098
1996	15154	175	2760	2935	15090	0.194
1997	13307	204	2402	2606	13206	0.197
1998	7391	152	1710	1862	7246	0.257
1999	9819	227	1684	1911	9690	0.197

Table 2. Lingcod commercial line, trawl, and total catches (tonnes) for Area 3C [1], 1927-2000. Superscripts correspond to sources of data and notes in Appendix I Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	245 [2]
1928	–	–	–	–	259
1929	–	–	–	–	186
1930	–	–	–	–	174
1931	–	–	–	–	101
1932	–	–	–	–	89
1933	–	–	–	–	89
1934	–	–	–	–	125
1935	–	–	–	–	243
1936	–	–	–	–	228
1937	–	–	–	–	35
1938	–	–	–	–	235
1939	–	–	–	–	153
1940	–	–	–	–	553
1941	–	–	–	–	229
1942	–	–	–	–	267
1943	–	–	–	–	354
1944	–	–	–	–	286
1945	79 [3]	206 [4]	–	206	285
1946	246	135	–	135	381
1947	– [6]	107	–	107	– [6]
1948	–	240	–	240	–
1949	–	375	–	375	–
1950	–	526	–	526	–
1951	212 [7]	514	–	514	726
1952	190	259	–	259	449
1953	83	269	–	269	352
1954	241	416 [8]	387 [9]	803	1044
1955	169	572	667	1239	1408
1956	156	730	411 [10]	1141	1297
1957	295	550	512	1062	1357
1958	156	493	545	1039	1194
1959	181	358	1371	1729	1910
1960	218	468	1399	1867	2085
1961	136	706	1266	1972	2108
1962	228	224	666	890	1118
1963	180	197	448	646	825
1964	101	426	757	1183	1284
1965	122	764	1125	1889	2011
1966	158	685	1368	2053	2211

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1967	246	794	990	1784	2030
1968	162	974	719	1694	1855
1969	171	618	465	1083	1253
1970	286	537	193	730	1016
1971	230	732	252	985	1214
1972	267	517	112	629	896
1973	184	786	94	880	1064
1974	226	956	89	1044	1270
1975	216	1225	424	1648	1865
1976	253	701	506	1207	1460
1977	267	628	216	844	1111
1978	200	355	6	362	562
1979	181	592	10	602	783
1980	213	622	1	623	836
1981	240	604	0	604	844
1982	220	1510	0	1510	1730
1983	170	971	–	971	1140
1984	128	1737	–	1737	1864
1985	192	3416	–	3416	3608
1986	268	834	–	834	1102
1987	234	492	–	492	727
1988	118	565	–	565	683
1989	131	848	–	848	979
1990	238	1177	–	1177	1415
1991	181	1265	–	1265	1446
1992	145	976	–	976	1121
1993	215	1428	–	1428	1642
1994	187 [11]	688	–	688	875
1995	198	805	–	805	1003
1996	111 [12]	748 [13]	–	748	859
1997	214	461	–	461	675
1998	197	523	–	523	720
1999	190	250	–	250	440

Table 3. Lingcod total trawl catch [1], qualified catch and effort [2], qualified CPUE [3], sample size (N), and the percent (P) of lingcod trawl catch that meets the qualification levels for Area 3C, 1954-1999.

Year	Total Canadian Catch (kg) [1]	25% Qualified [2] (May-September)						
		Catch (kg)	Effort (h)	CPUE (kg/h) [3]	$N_{Landings}$	N_{Events}	N_{Sets}	P
1954	371469	236041	1921	123	1009	93	78	63.5
1955	539578	428843	1806	237	1020	127	85	79.5
1956	570520	429535	1385	310	807	99	64	75.3
1957	431860	384609	1290	298	790	78	55	89.1
1958	386548	332997	936	356	628	61	46	86.1
1959	284160	221416	710	312	461	44	36	77.9
1960	353847	288049	1348	214	762	68	46	81.4
1961	497840	390347	1252	312	862	87	56	78.4
1962	180630	152101	669	227	434	48	27	84.2
1963	171471	146048	423	345	353	36	26	85.2
1964	309924	261539	624	419	444	44	28	84.4
1965	512711	436699	1187	368	654	58	41	85.2
1966	497307	435404	1415	308	773	94	58	87.6
1967	716983	658302	1558	423	887	85	52	91.8
1968	857458	456496	757	603	505	60	31	53.2
1969	472839	437110	1513	289	847	71	52	92.4
1970	509759	468689	1664	282	867	72	48	91.9
1971	649029	548646	1532	358	821	87	66	84.5
1972	473373	265237	926	286	501	56	43	56.0
1973	607546	434437	1239	351	582	43	36	71.5
1974	709254	528700	1742	303	848	53	36	74.5
1975	1103985	955236	2582	370	1300	99	71	86.5
1976	582014	456925	1845	248	894	78	52	78.5
1977	560582	362893	1259	288	691	68	44	64.7
1978	294821	185416	821	226	420	50	31	62.9
1979	446212	381105	1464	260	781	72	47	85.4
1980	363248	295746	1047	283	583	67	44	81.4
1981	406054	321280	1227	262	595	56	34	79.1
1982	1208108	1101284	2674	412	1271	89	60	91.2
1983	558030	514487	1383	372	653	62	37	92.2
1984	997055	904445	2032	445	1056	80	49	90.7
1985	1894292	1811164	3408	531	1533	99	68	95.6
1986	455297	387615	1021	380	575	59	44	85.1
1987	348270	287239	1393	206	853	80	55	82.5
1988	475035	314289	1509	208	856	95	73	66.2
1989	837611	722763	2289	316	1218	150	123	86.3
1990	1155190	958237	3444	278	1626	203	144	83.0
1991	1235360	1114260	4284	260	173	–	–	90.2
1992	961945	682290	2224	307	170	–	–	70.9
1993	1413218	911530	1501	607	142	–	–	64.5
1994	683642	302760	1383	219	107	–	–	44.3
1995	785750	552990	2365	234	116	–	–	70.4
1996	747834	127138	892	143	81	–	345	17.0
1997	460515	40994	181	226	24	–	103	8.9
1998	523038	46573	107	437	25	–	67	8.9
1999	249687	115473	493	234	38	–	202	46.2

[1] Canadian trawl catch with associated effort data only: logbook data (source 1) from the GFCatch (1954-1995) and PacHarvest (1996-1999) databases (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[2] Qualified catch and effort is the lingcod catch and associated effort from landings occurring in May-September for those sets or events where the non-discarded lingcod catch is greater than 25% of the total catch.

[3] CPUE is based on tow-by-tow data after 1995; aggregated by tow within locality prior to 1995. Aggregation is simulated for 1991-1995, hence N_{Events} and N_{Sets} not available for these years. Each aggregate is considered one fishing "event."

Table 4. Lingcod recreational catch, effort, and CPUE for Barkley Sound, based on creel survey data during August and September, 1984-1992 (D. Lewis, pers. comm., Stock Assessment Division, Science Branch, Fisheries and Oceans Canada, 3225 Stephenson Point Road, Nanaimo, BC, V9T 1K3).

Year	Catch (pieces)	Effort (boat trips)	CPUE (pieces per 10 trips)
1984	1821	21439	0.85
1985	4016	21772	1.84
1986	259	7437	0.35
1987	3351	24383	1.37
1988	4163	24670	1.69
1989	5849	36946	1.58
1990	2154	42864	0.5
1991	2059	40792	0.5
1992	2840	55140	0.52
1993	2855	39918	0.72
1994	4213	46276	0.91
1995	2729	30901	0.88
1996	1285	6504	1.98
1997	2167	18910	1.15
1998	3191	18641	1.71
1999	822	25400	0.32

Table 5. Lingcod commercial line, trawl, and total catches (tonnes) for Area 3D, 1927-1999. Superscripts correspond to sources of data and notes in Appendix I Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	44 [2]
1928	–	–	–	–	64
1929	–	–	–	–	13
1930	–	–	–	–	36
1931	–	–	–	–	4
1932	–	–	–	–	0
1933	–	–	–	–	0
1934	–	–	–	–	0
1935	–	–	–	–	3
1936	–	–	–	–	7
1937	–	–	–	–	4
1938	–	–	–	–	1
1939	–	–	–	–	3
1940	–	–	–	–	6
1941	–	–	–	–	6
1942	–	–	–	–	8
1943	–	–	–	–	620
1944	–	–	–	–	164
1945	– [5]	287 [4]	–	287	– [5]
1946	–	175	–	175	–
1947	– [6]	53	–	53	– [6]
1948	–	24	–	24	–
1949	–	73	–	73	–
1950	–	88	–	88	–
1951	168 [7]	73	–	73	240
1952	185	61	–	61	246
1953	89	34	–	34	123
1954	140	36 [8]	24 [9]	60	199
1955	93	66	90	156	249
1956	125	55	112 [10]	167	292
1957	135	83	45	129	264
1958	120	49	59	108	228
1959	94	10	53	64	158
1960	106	37	50	87	193
1961	116	71	128	200	315
1962	104	52	233	286	390
1963	122	52	64	115	238
1964	85	199	27	226	311
1965	90	423	82	505	596
1966	136	526	59	585	721

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1967	167	375	85	460	626
1968	108	719	150	868	976
1969	78	513	106	619	696
1970	159	379	77	456	614
1971	115	214	50	264	379
1972	182	65	19	85	267
1973	84	114	58	172	257
1974	113	129	113	242	355
1975	90	146	200	346	437
1976	91	110	135	245	335
1977	108	96	62	158	265
1978	88	185	12	196	284
1979	101	92	54	147	248
1980	88	86	40	127	214
1981	113	75	12	87	200
1982	175	49	0	49	223
1983	153	447	–	447	600
1984	153	322	–	322	475
1985	194	380	–	380	574
1986	229	246	–	246	475
1987	327	88	–	88	415
1988	242	283	–	283	525
1989	196	300	–	300	495
1990	241	421	–	421	661
1991	284	549	–	549	833
1992	310	554	–	554	864
1993	673	448	–	448	1122
1994	552 [11]	847	–	847	1400
1995	373	502	–	502	874
1996	182 [12]	197 [13]	–	197	379
1997	230	83	–	83	313
1998	258	132	–	132	390
1999	206	106	–	106	312

Table 6. Lingcod total trawl catch [1], qualified catch and effort [2], qualified CPUE [3], sample size (N), and the percent (P) of lingcod trawl catch that meets the qualification levels for Area 3D, 1954-1999.

Year	Total Canadian Catch (kg) [1]	25% Qualified [2] (May-September)						
		Catch (kg)	Effort (h)	CPUE (kg/h) [3]	$N_{Landings}$	N_{Events}	N_{Sets}	P
1954	35523	25477	142	179	93	14	11	71.7
1955	65565	44324	211	210	132	13	13	67.6
1956	54799	44063	140	315	92	13	13	80.4
1957	78625	71105	259	275	159	18	11	90.4
1958	47482	23060	127	182	88	15	10	48.6
1959	10408	9246	23	402	25	4	4	88.8
1960	37189	33052	68	486	49	8	5	88.9
1961	65491	61649	201	307	131	17	13	94.1
1962	51485	38622	213	181	142	26	16	75.0
1963	36451	31694	123	258	70	10	8	87.0
1964	194795	186546	510	366	291	25	22	95.8
1965	423007	414048	1445	287	713	49	44	97.9
1966	526146	509146	1159	439	571	54	42	96.8
1967	374481	328919	833	395	395	41	33	87.8
1968	672941	649374	1196	543	626	70	54	96.5
1969	497782	492407	1667	295	824	103	60	98.9
1970	378899	367178	1352	272	638	95	44	96.9
1971	192710	171362	837	205	397	67	39	88.9
1972	63741	60242	317	190	134	19	16	94.5
1973	103006	96694	246	393	109	14	13	93.9
1974	129320	119390	221	541	141	28	8	92.3
1975	117538	109044	385	284	210	33	16	92.8
1976	100880	86775	277	313	125	28	14	86.0
1977	95826	86317	283	305	156	41	16	90.1
1978	174145	132551	278	477	195	44	25	76.1
1979	42193	25620	82	314	43	17	7	60.7
1980	44284	20495	95	215	48	16	12	46.3
1981	40357	31702	145	218	77	17	12	78.6
1982	21214	6629	35	191	17	7	6	31.2
1983	313332	224976	668	337	283	44	24	71.8
1984	185611	135140	480	282	207	29	23	72.8
1985	202496	56980	115	498	48	12	11	28.1
1986	103756	49662	157	316	75	27	16	47.9
1987	82159	28594	92	309	48	13	9	34.8
1988	232002	109637	347	316	162	35	28	47.3
1989	298045	175982	628	280	286	40	37	59.0
1990	388576	271735	734	370	312	55	44	69.9
1991	526497	344030	1323	260	76	–	–	65.3
1992	551788	252040	1069	236	109	–	–	45.7
1993	418719	125430	729	172	103	–	–	30.0
1994	842775	580750	2033	286	124	–	–	68.9
1995	476928	240510	1257	191	111	–	–	50.4
1996	196735	74623	353	211	74	–	193	37.9
1997	83151	16698	64	263	20	–	36	20.1
1998	131826	31404	81	386	24	–	50	23.8
1999	105795	34036	108	316	31	–	69	32.2

[1] Canadian trawl catch with associated effort data only: logbook data (source 1) from the GFCatch (1954-1995) and PacHarvest (1996-1999) databases (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[2] Qualified catch and effort is the lingcod catch and associated effort from landings occurring in May-September for those sets or events where the non-discarded lingcod catch is greater than 25% of the total catch.

[3] CPUE is based on tow-by-tow data after 1995; aggregated by tow within locality prior to 1995. Aggregation is simulated for 1991-1995, hence N_{Events} and N_{Sets} not available for these years. Each aggregate is considered one fishing "event."

Table 7. Lingcod commercial line, trawl, and total catches (tonnes) for Area 5A/B, 1927-1999. Superscripts correspond to sources of data and notes in Appendix I Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	0 [2]
1928	–	–	–	–	0
1929	–	–	–	–	0
1930	–	–	–	–	1
1931	–	–	–	–	0
1932	–	–	–	–	0
1933	–	–	–	–	0
1934	–	–	–	–	0
1935	–	–	–	–	3
1936	–	–	–	–	1
1937	–	–	–	–	1
1938	–	–	–	–	1
1939	–	–	–	–	3
1940	–	–	–	–	7
1941	–	–	–	–	39
1942	–	–	–	–	54
1943	–	–	–	–	86
1944	–	–	–	–	153
1945	224 [3]	32 [4]	–	32	256
1946	175	56	–	56	231
1947	– [6]	16	–	16	– [6]
1948	–	47	–	47	–
1949	–	95	–	95	–
1950	–	46	–	46	–
1951	35 [7]	80	–	80	115
1952	32	71	–	71	103
1953	4	17	–	17	21
1954	10	51 [8]	166 [9]	217	227
1955	19	50	215	265	284
1956	35	236	359 [10]	595	630
1957	12	252	345	598	610
1958	2	309	258	568	569
1959	4	369	247	616	620
1960	23	307	351	658	680
1961	49	366	345	711	760
1962	69	497	441	938	1007
1963	77	242	400	642	719
1964	33	373	315	687	720
1965	23	226	671	897	920
1966	59	478	1056	1533	1592
1967	40	413	1247	1660	1700
1968	41	766	1503	2269	2311
1969	57	377	756	1134	1191
1970	82	268	712	980	1062
1971	58	287	367	654	713
1972	109	267	373	640	749
1973	67	166	415	582	648
1974	84	253	618	871	955
1975	75	320	212	532	607
1976	92	415	186	602	694
1977	78	300	78	378	456
1978	39	273	15	288	327
1979	54	320	21	342	396
1980	58	399	14	413	471
1981	49	730	0	730	779
1982	54	1047	0	1047	1101
1983	57	1345	–	1345	1402
1984	75	716	–	716	790
1985	85	877	–	877	962
1986	61	1651	–	1651	1713
1987	131	1431	–	1431	1562
1988	125	1291	–	1291	1415
1989	159	1616	–	1616	1775
1990	200	2119	–	2119	2319
1991	305	1857	–	1857	2162
1992	262	1262	–	1262	1524
1993	102	1421	–	1421	1524
1994	129 [11]	1334	–	1334	1462
1995	166	1239	–	1239	1406
1996	181 [12]	633 [13]	–	633	814
1997	140	386	–	386	526
1998	184	423	–	423	607
1999	175	533	–	533	708

Table 8. Lingcod total trawl catch [1], qualified catch and effort [2], qualified CPUE [3], sample size (N), and the percent (P) of lingcod trawl catch that meets the qualification levels for Area 5A/B, 1954-1999.

Year	Total Canadian Catch (kg) [1]	25% Qualified [2] (May-September)						
		Catch (kg)	Effort (h)	CPUE (kg/h) [3]	$N_{Landings}$	N_{Events}	N_{Sets}	P
1954	49134	20544	40	514	31	5	5	41.8
1955	43612	13717	98	140	66	4	4	31.5
1956	192882	135097	457	296	289	27	24	70.0
1957	234123	141286	572	247	323	39	29	60.3
1958	301148	206513	1012	204	521	59	43	68.6
1959	360316	275664	883	312	509	58	43	76.5
1960	303172	184051	732	251	446	55	40	60.7
1961	365572	294785	907	325	535	56	35	80.6
1962	497020	408130	1619	252	947	84	61	82.1
1963	237706	172664	848	204	484	64	38	72.6
1964	367287	238219	942	253	509	69	52	64.9
1965	224799	124219	562	221	297	53	43	55.3
1966	473064	368248	1239	297	652	95	71	77.8
1967	412161	257182	823	313	429	81	54	62.4
1968	744196	656587	2317	283	1161	167	110	88.2
1969	377137	263410	1868	141	786	115	72	69.8
1970	268214	202163	917	220	428	90	62	75.4
1971	275708	176912	1281	138	531	74	55	64.2
1972	260879	121317	625	194	214	35	23	46.5
1973	164984	102166	630	162	268	33	22	61.9
1974	237493	130910	499	262	150	19	18	55.1
1975	295495	135452	733	185	256	45	37	45.8
1976	412889	172236	692	249	231	52	44	41.7
1977	295175	137444	721	191	276	42	36	46.6
1978	266495	117702	540	218	223	34	30	44.2
1979	302471	83550	376	222	136	29	26	27.6
1980	390182	167899	789	213	313	63	48	43.0
1981	698486	551449	2039	270	778	114	57	78.9
1982	1004890	806058	3024	267	1183	149	72	80.2
1983	1130634	977273	2991	327	1197	152	81	86.4
1984	473770	360656	1700	212	611	76	46	76.1
1985	710623	586828	2093	280	808	67	45	82.6
1986	1508667	1332753	3080	433	1138	111	74	88.3
1987	1303245	771852	2647	292	915	134	101	59.2
1988	1259864	811740	2606	311	943	127	100	64.4
1989	1541854	1019096	3200	318	1072	143	108	66.1
1990	2085681	1399037	4772	293	1635	240	172	67.1
1991	1761269	1119020	3876	289	220	–	–	63.5
1992	1236096	554570	2555	217	178	–	–	44.9
1993	1368866	614770	2526	243	194	–	–	44.9
1994	1314934	958740	4517	212	240	–	–	72.9
1995	1154918	910970	5412	168	326	–	–	78.9
1996	633311	463759	2362	196	253	–	1068	73.2
1997	385555	234507	1080	217	143	–	525	60.8
1998	422844	297635	1488	200	180	–	676	70.4
1999	533242	375774	2167	173	191	–	953	70.5

[1] Canadian trawl catch with associated effort data only: logbook data (source 1) from the GFCatch (1954-1995) and PacHarvest (1996-1999) databases (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[2] Qualified catch and effort is the lingcod catch and associated effort from landings occurring in May-September for those sets or events where the non-discarded lingcod catch is greater than 25% of the total catch.

[3] CPUE is based on tow-by-tow data after 1995; aggregated by tow within locality prior to 1995. Aggregation is simulated for 1991-1995, hence N_{Events} and N_{Sets} not available for these years. Each aggregate is considered one fishing "event."

Table 9. Lingcod commercial line, trawl, and total catches (tonnes) for Area 5C/D, 1927-1999. Superscripts correspond to sources of data and notes in Appendix I Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	13 [2]
1928	–	–	–	–	26
1929	–	–	–	–	35
1930	–	–	–	–	17
1931	–	–	–	–	1
1932	–	–	–	–	3
1933	–	–	–	–	4
1934	–	–	–	–	1
1935	–	–	–	–	6
1936	–	–	–	–	6
1937	–	–	–	–	6
1938	–	–	–	–	7
1939	–	–	–	–	8
1940	–	–	–	–	7
1941	–	–	–	–	8
1942	–	–	–	–	22
1943	–	–	–	–	72
1944	–	–	–	–	117
1945	163 [3]	16 [4]	–	16	179
1946	247	245	–	245	492
1947	– [6]	9	–	9	– [6]
1948	–	115	–	115	–
1949	–	182	–	182	–
1950	–	94	–	94	–
1951	53 [7]	136	–	136	189
1952	47	62	–	62	109
1953	5	22	–	22	28
1954	9	25 [8]	75 [9]	100	109
1955	3	38	178	216	219
1956	5	38	54 [10]	92	97
1957	6	57	71	128	134
1958	9	35	39	74	83
1959	17	57	59	116	133
1960	22	82	34	116	138
1961	34	63	33	96	130
1962	54	100	13	113	167
1963	47	117	29	146	193
1964	43	192	23	215	257
1965	64	234	21	255	319
1966	47	258	7	264	311
1967	62	256	69	325	387
1968	65	378	5	383	448
1969	92	244	0	244	336
1970	120	207	1	209	328
1971	136	265	58	323	459
1972	128	154	0	154	282
1973	93	123	0	123	216
1974	113	119	1	120	233
1975	107	170	0	170	276
1976	74	98	1	98	172
1977	63	120	0	120	183
1978	56	48	0	48	104
1979	64	128	0	128	192
1980	89	170	0	170	259
1981	52	265	0	266	317
1982	84	192	0	192	276
1983	108	144	–	144	251
1984	128	145	–	145	273
1985	176	138	–	138	314
1986	177	136	–	136	313
1987	324	367	–	367	691
1988	290	349	–	349	639
1989	286	272	–	272	558
1990	371	304	–	304	675
1991	317	528	–	528	846
1992	290	445	–	445	735
1993	296	456	–	456	752
1994	203 [11]	546	–	546	749
1995	284	555	–	555	838
1996	95 [12]	175 [13]	–	175	270
1997	78	99	–	99	177
1998	108	67	–	67	175
1999	191	67	–	67	258

Table 10. Lingcod total trawl catch [1], qualified catch and effort [2], qualified CPUE [3], sample size (N), and the percent (P) of lingcod trawl catch that meets the qualification levels for Area 5C/D, 1954-1999.

Year	Total Canadian Catch (kg) [1]	25% Qualified [2] (May-September)						
		Catch (kg)	Effort (h)	CPUE (kg/h) [3]	$N_{Landings}$	N_{Events}	N_{Sets}	P
1954	24162	1847	3	616	3	1	1	7.6
1955	31186	5991	7	856	7	1	1	19.2
1956	28651	3318	15	221	12	1	1	11.6
1957	35303	6105	7	872	4	1	1	17.3
1958	26557	742	6	124	6	3	2	2.8
1959	56389	1771	22	81	14	3	3	3.1
1960	76786	4779	34	141	30	3	2	6.2
1961	57045	2573	24	107	17	4	4	4.5
1962	86915	1189	7	170	5	2	2	1.4
1963	106265	33750	98	344	82	8	8	31.8
1964	178199	75017	165	455	96	13	10	42.1
1965	215502	67788	76	892	52	12	11	31.5
1966	239680	40020	100	399	55	11	10	16.7
1967	242366	100840	290	347	159	22	18	41.6
1968	341463	120451	476	253	256	37	35	35.3
1969	229587	65621	418	157	230	38	31	28.6
1970	192663	49483	252	196	138	16	14	25.7
1971	259073	143948	531	271	268	40	33	55.6
1972	126865	28025	71	398	41	8	8	22.1
1973	107636	15543	43	359	26	6	6	14.4
1974	94759	1934	26	76	13	4	4	2.0
1975	136860	30863	51	611	36	9	9	22.6
1976	69297	6739	24	281	14	6	6	9.7
1977	111342	1824	10	192	7	3	3	1.6
1978	47003	254	14	18	7	2	2	0.5
1979	118045	16607	72	232	37	10	10	14.1
1980	142995	6428	59	109	32	15	15	4.5
1981	201805	21511	96	223	45	17	17	10.7
1982	189633	62705	234	268	119	14	13	33.1
1983	135617	43143	213	203	114	16	16	31.8
1984	141870	6217	55	113	32	8	8	4.4
1985	126912	35339	140	252	71	11	11	27.8
1986	133006	22991	97	236	60	13	12	17.3
1987	311300	49651	120	413	72	18	17	15.9
1988	338597	93195	268	348	131	31	29	27.5
1989	266523	26532	84	315	41	14	14	10.0
1990	303779	68094	229	297	104	26	24	22.4
1991	522030	163120	594	275	48	–	–	31.2
1992	439059	100990	351	288	49	–	–	23.0
1993	452059	148670	505	295	71	–	–	32.9
1994	527363	153860	311	495	42	–	–	29.2
1995	548175	207810	679	306	65	–	–	37.9
1996	175222	102194	378	271	62	–	204	58.3
1997	99288	17411	99	176	39	–	61	17.5
1998	66785	13278	117	113	37	–	68	19.9
1999	67166	19855	76	260	29	–	51	29.6

[1] Canadian trawl catch with associated effort data only: logbook data (source 1) from the GFCatch (1954-1995) and PacHarvest (1996-1999) databases (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[2] Qualified catch and effort is the lingcod catch and associated effort from landings occurring in May-September for those sets or events where the non-discarded lingcod catch is greater than 25% of the total catch.

[3] CPUE is based on tow-by-tow data after 1995; aggregated by tow within locality prior to 1995. Aggregation is simulated for 1991-1995, hence N_{Events} and N_{Sets} not available for these years. Each aggregate is considered one fishing "event."

Table 11. Lingcod commercial line, trawl, and total catches (tonnes) for Area 5E, 1927-1999. Superscripts correspond to sources of data and notes in Appendix I Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	–
1928	–	–	–	–	–
1929	–	–	–	–	–
1930	–	–	–	–	–
1931	–	–	–	–	–
1932	–	–	–	–	–
1933	–	–	–	–	–
1934	–	–	–	–	–
1935	–	–	–	–	–
1936	–	–	–	–	–
1937	–	–	–	–	–
1938	–	–	–	–	–
1939	–	–	–	–	–
1940	–	–	–	–	–
1941	–	–	–	–	–
1942	–	–	–	–	–
1943	–	–	–	–	–
1944	–	–	–	–	–
1945	–	–	–	–	–
1946	–	–	–	–	–
1947	–	–	–	–	–
1948	–	–	–	–	–
1949	–	–	–	–	–
1950	–	–	–	–	–
1951	14 [7]	–	–	–	14
1952	2	–	–	–	2
1953	0	–	–	–	0
1954	1	–	–	–	1
1955	0	–	–	–	0
1956	0	–	–	–	0
1957	3	–	–	–	3
1958	0	–	–	–	0
1959	1	–	–	–	1
1960	1	–	–	–	1
1961	2	–	–	–	2
1962	4	–	–	–	4
1963	5	–	–	–	5
1964	6	–	–	–	6
1965	10	–	–	–	10
1966	7	–	–	–	7

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1967	7	–	–	–	7
1968	4	–	–	–	4
1969	13	–	–	–	13
1970	10	–	–	–	10
1971	16	–	–	–	16
1972	11	–	–	–	11
1973	9	–	–	–	9
1974	18	–	–	–	18
1975	15	–	–	–	15
1976	13	0	–	0	13
1977	5	5	–	5	10
1978	7	3	–	3	10
1979	13	1	–	1	14
1980	19	4	–	4	23
1981	20	1	–	1	21
1982	25	2	–	2	27
1983	13	1	–	1	14
1984	45	9	–	9	53
1985	28	15	–	15	43
1986	49	13	–	13	62
1987	54	6	–	6	60
1988	79	20	–	20	99
1989	73	20	–	20	93
1990	73	28	–	28	101
1991	58	10	–	10	68
1992	106	9	–	9	114
1993	160	10	–	10	170
1994	138 [11]	12	–	12	150
1995	63	8	–	8	72
1996	101 [12]	7 [13]	–	7	108
1997	75	8	–	8	83
1998	94	6	–	6	100
1999	216	4	–	4	220

Table 12. Lingcod total trawl catch [1], qualified catch and effort [2], qualified CPUE [3], sample size (N), and the percent (P) of lingcod trawl catch that meets the qualification levels for Area 5E, 1954-1999.

Year	Total Canadian Catch (kg) [1]	25% Qualified [2] (May-September)						
		Catch (kg)	Effort (h)	CPUE (kg/h) [3]	$N_{Landings}$	N_{Events}	N_{Sets}	P
1970	15	–	–	–	–	–	–	–
1971	0	–	–	–	–	–	–	–
1972	0	–	–	–	–	–	–	–
1973	0	–	–	–	–	–	–	–
1974	0	–	–	–	–	–	–	–
1975	0	–	–	–	–	–	–	–
1976	26	–	–	–	–	–	–	–
1977	3000	–	–	–	–	–	–	–
1978	3411	–	–	–	–	–	–	–
1979	1158	–	–	–	–	–	–	–
1980	2052	–	–	–	–	–	–	–
1981	580	–	–	–	–	–	–	–
1982	318	–	–	–	–	–	–	–
1983	1302	76	7	12	3	1	1	5.8
1984	7611	–	–	–	–	–	–	–
1985	11933	–	–	–	–	–	–	–
1986	11638	–	–	–	–	–	–	–
1987	5627	–	–	–	–	–	–	–
1988	19631	–	–	–	–	–	–	–
1989	19989	–	–	–	–	–	–	–
1990	27773	–	–	–	–	–	–	–
1991	10274	–	–	–	–	–	–	–
1992	8794	50	2	25	1	–	–	0.6
1993	9418	490	2	213	2	–	–	5.2
1994	11842	110	6	19	2	–	–	0.9
1995	8354	770	3	285	1	–	–	9.2
1996	7423	–	–	–	–	–	–	–
1997	7916	–	–	–	–	–	–	–
1998	5522	–	–	–	–	–	–	–
1999	4227	–	–	–	–	–	–	–

[1] Canadian trawl catch with associated effort data only: logbook data (source 1) from the GFCatch (1954-1995) and PacHarvest (1996-1999) databases (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[2] Qualified catch and effort is the lingcod catch and associated effort from landings occurring in May-September for those sets or events where the non-discarded lingcod catch is greater than 25% of the total catch.

[3] CPUE is based on tow-by-tow data after 1995; aggregated by tow within locality prior to 1995. Aggregation is simulated for 1991-1995, hence N_{Events} and N_{Sets} not available for these years. Each aggregate is considered one fishing "event."

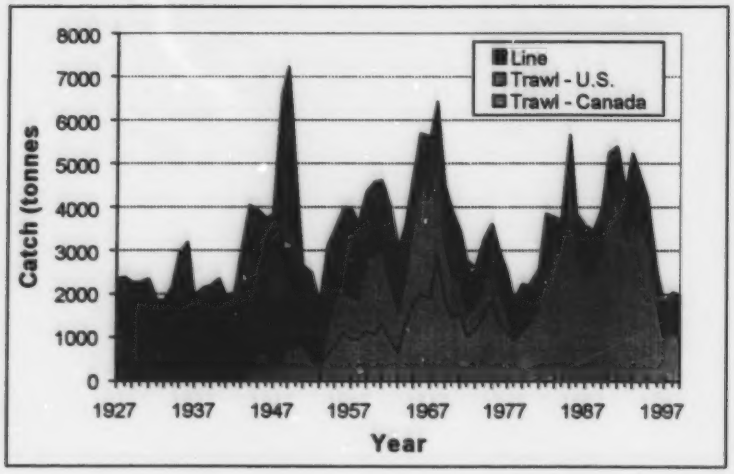


Figure 1. Coast-wide lingcod commercial catch (Canadian Line, Canadian Trawl, U.S. Trawl) for British Columbia, 1927-1999.

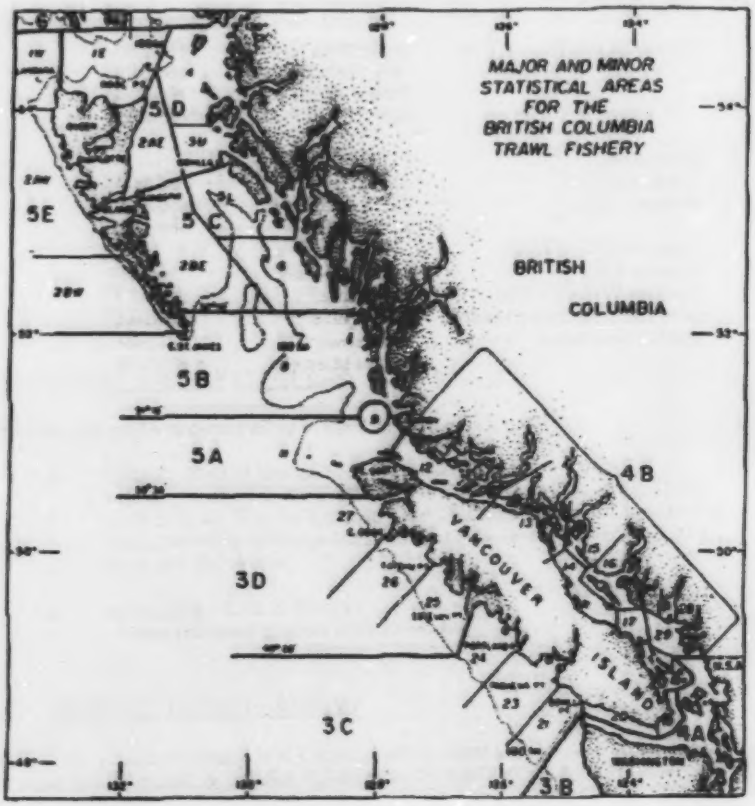


Figure 2. Groundfish major statistical areas for the British Columbia Coast.

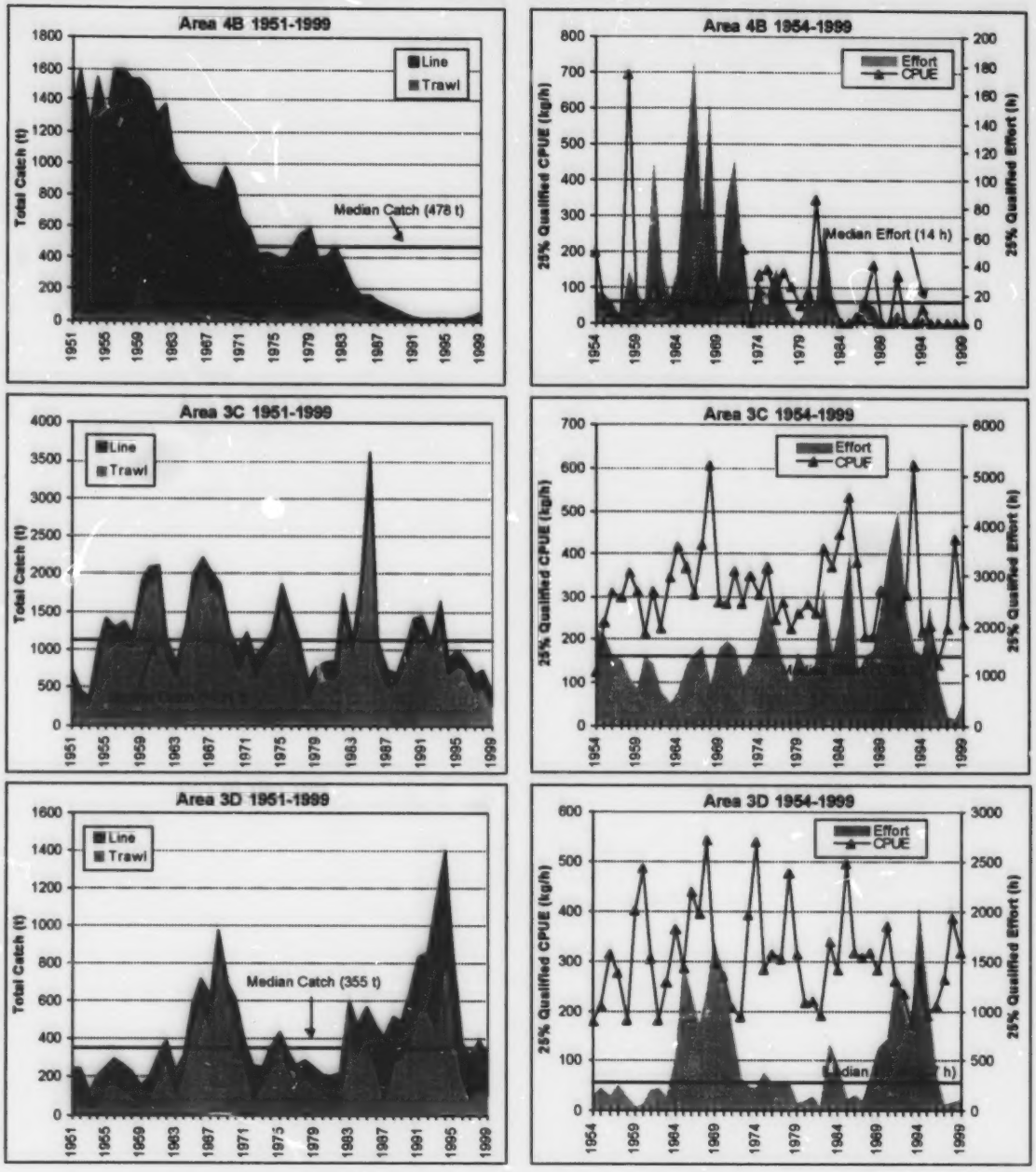
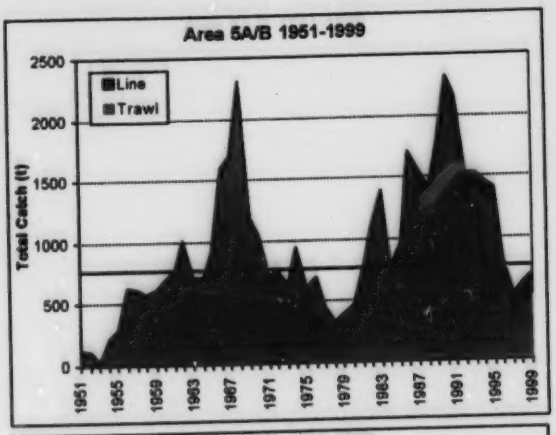
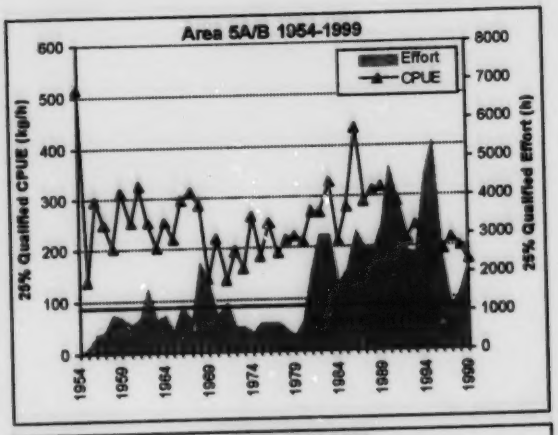
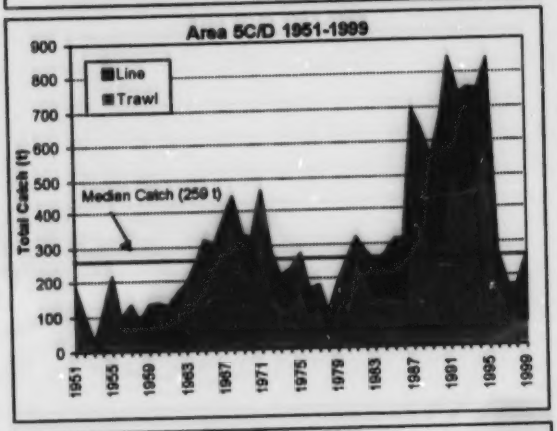
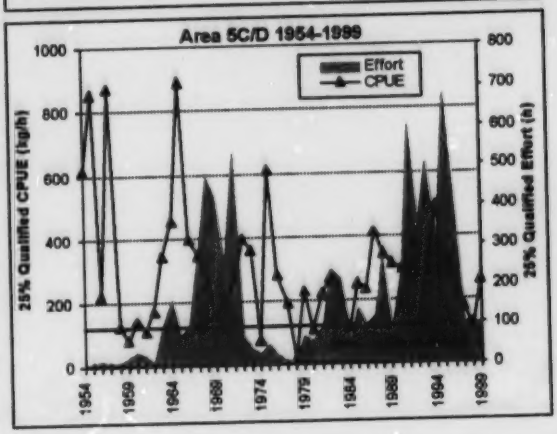


Figure 3. Total Canadian catch for the commercial lingcod hook and line fishery (1951-1998) and trawl fishery (1951-1999), and 25% Qualified effort and CPUE for the lingcod trawl fishery (1954-1999), in the Strait of Georgia (Area 4B), off the west coast of Vancouver Island (Areas 3C and 3D), in Queen Charlotte Sound (Areas 5A and 5B), in Hecate Strait (Areas 5C and 5D) and off the west coast of the Queen Charlotte Islands (Area 5E). Note that for Area 5E, only five years had Qualified catch, and the 25% Qualified effort and CPUE plot is not shown.









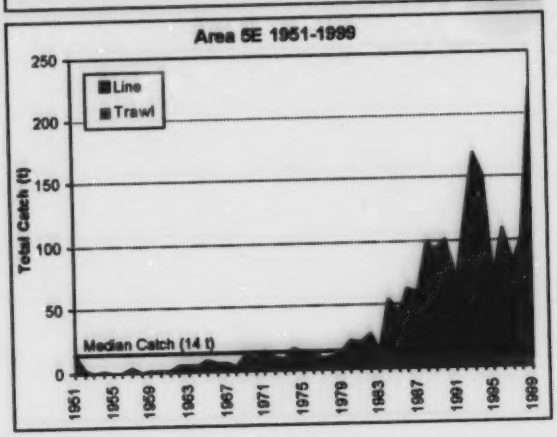


Figure 3 (cont.).

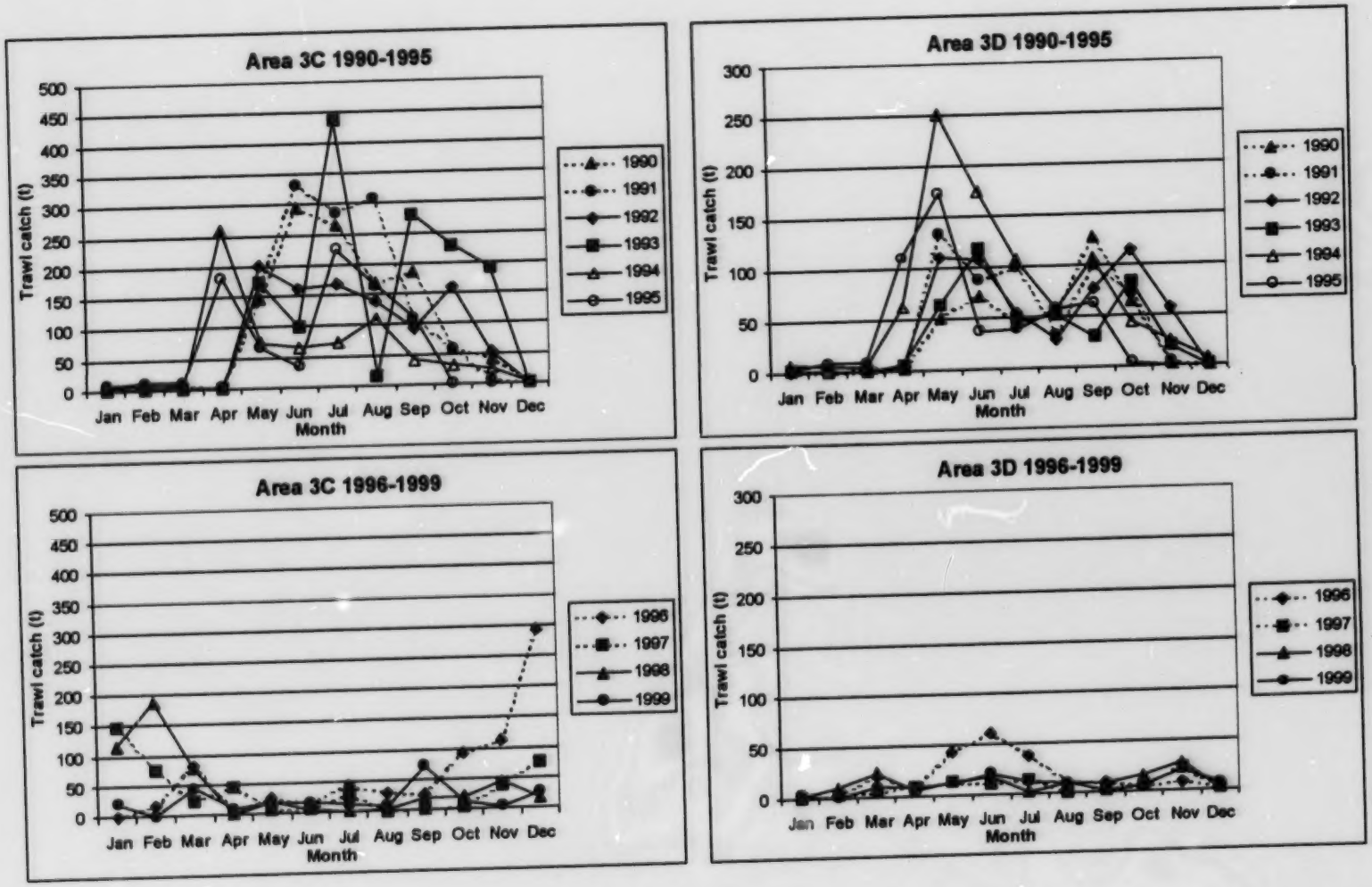


Figure 4. Total trawl catch by month for lingcod caught off the west coast of Vancouver Island (Areas 3C and 3D) in 1990-1995, and 1996-1999.

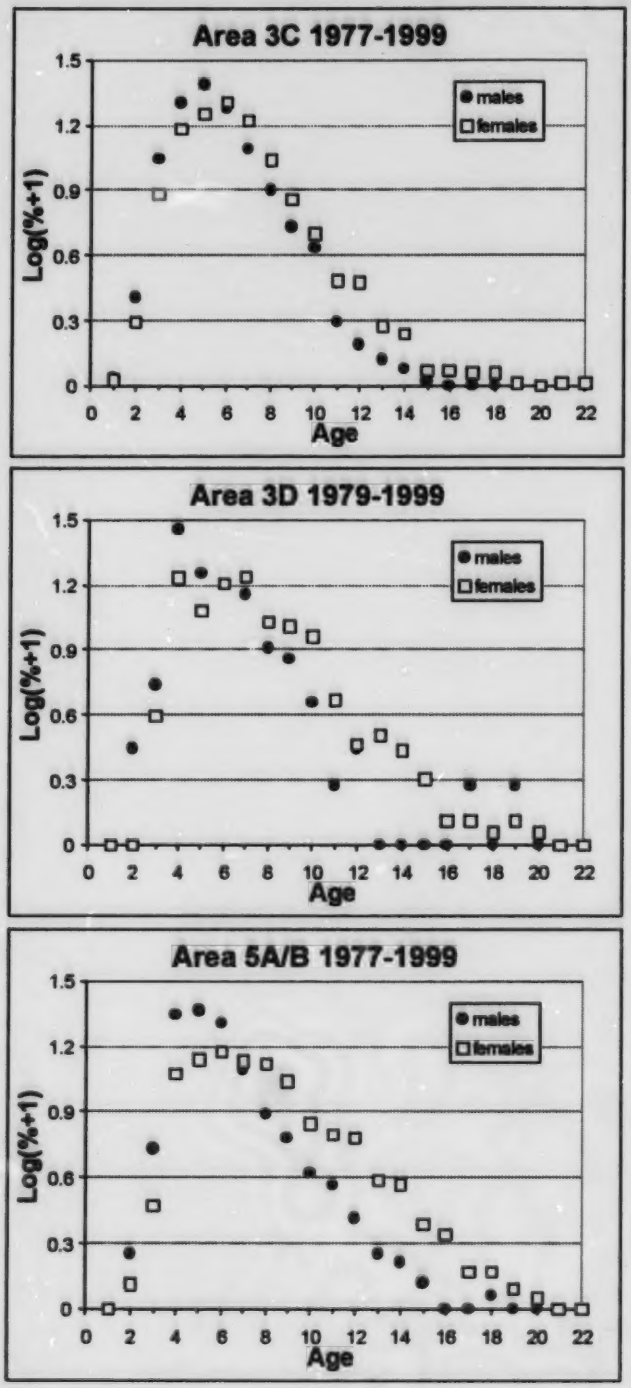


Figure 5. Catch curves for lingcod caught in the trawl fishery off the west coast of Vancouver Island (Areas 3C and 3D), and in Queen Charlotte Sound (Area 5A/B), January to December, 1977-1999.

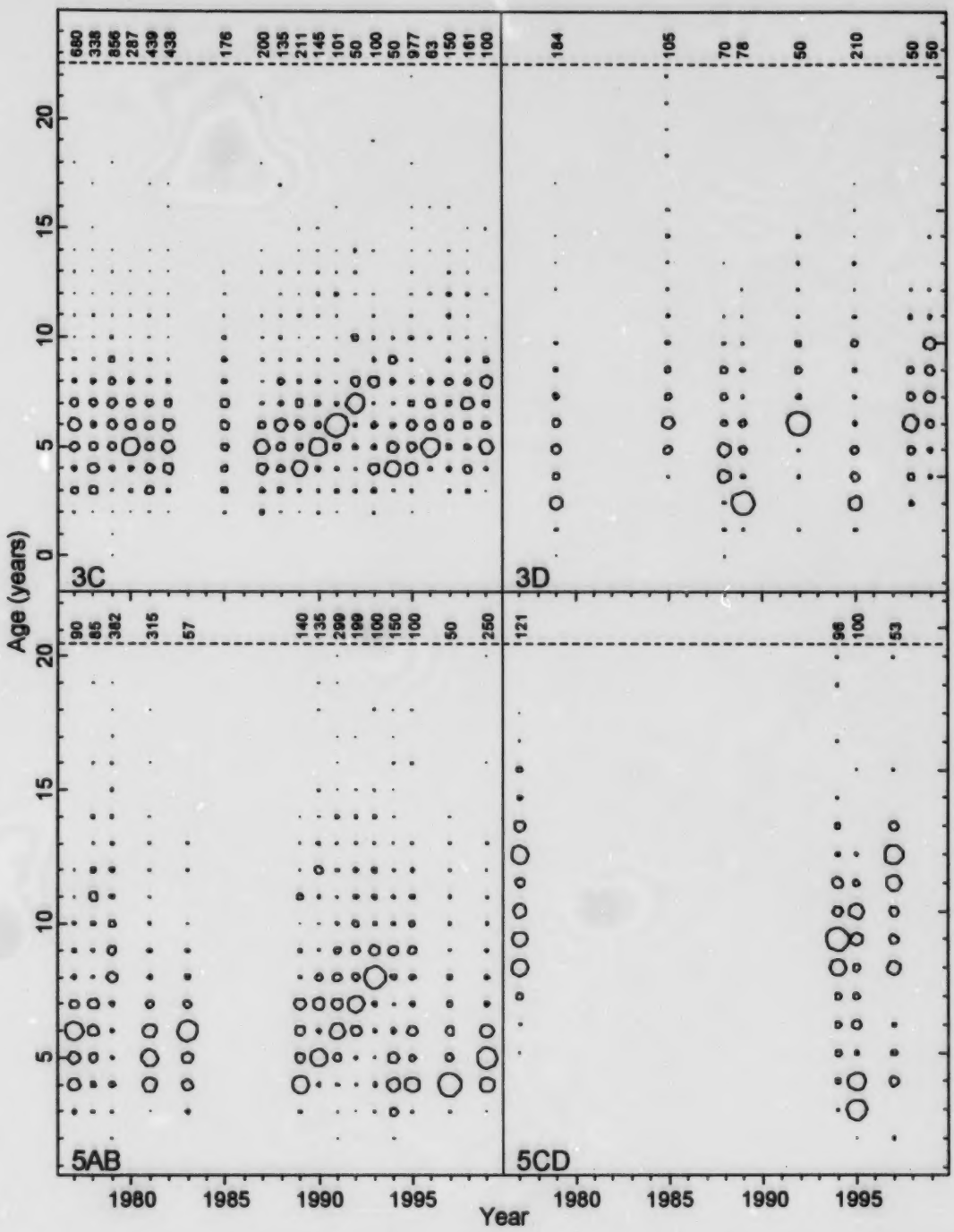


Figure 6. Proportion-at-age bubble plots for trawl-caught lingcod in Areas 3C, 3D, 5A/B and 5C/D, January-December, 1977-1999. Numbers along upper side of plots indicate number of specimens aged in each year.

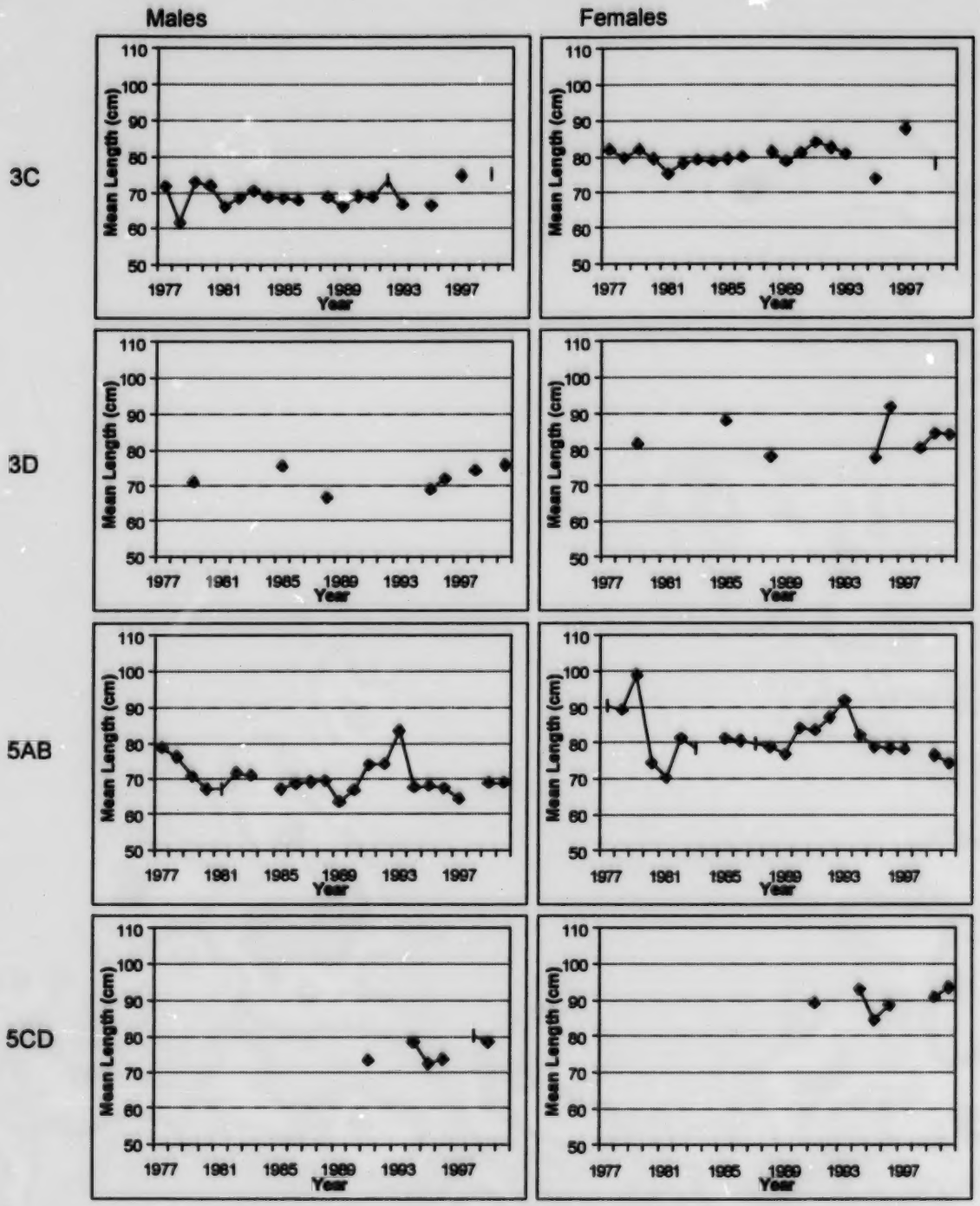


Figure 7. Mean size of lingcod collected off the west coast of Vancouver Island (Areas 3C and 3D), in Queen Charlotte Sound (Areas 5A and 5B), and in Hecate Strait (Areas 5C and 5D), May-September, 1977-2000. Note that samples were not collected in all years.

Appendix I: Lingcod commercial catch data for British Columbia

Table A1. Sources of lingcod commercial catch data (1927-1999).

No.[a] Years and Data Type	Sources and Notes
1. 1954-1974 Area 3C Trawl Catch	Prior to 1975, no distinction was made between the Canadian and United States portions of Area 3C. Catch for these years therefore includes a small amount from U.S. waters.
2. 1927-1946 Total Catch	Dominion Bureau of Statistics, Fisheries Division (in Waddell and Ware 1995). Catches were reported as dressed weight, DW (head and viscera removed; Wilby 1937), and converted to round weight, RW, using the formula RW = 1.39 * DW (K. Rutherford, Pers. Comm.). Catch was not reported by gear type, but is known to be primarily from the line fishery, especially in nearshore waters (Forrester et al. 1978).
3. 1945-1946 Line	Calculated from the difference between (2) and (4)
4. 1945-1953 Canadian Trawl	Thomson and Yates (1960, 1961a, 1961b). Data obtained by Port Observers and supplemented with sales slip records.
5. 1945-1946 Area 3D Catch	Total catch (2) for these years in Area 3D was less than trawl catch (4) suggesting that an error may have occurred when the data was tabulated. Trawl catch is assumed to be correct, as it is based on two complementary DFO sources. Total catch and line catch are omitted.
6. 1947-1950 Line and Total Catch	No area totals available for line or total catch. Coastwide total catch reported in Dominion Bureau of Statistics, Fisheries Division (Appendix Table 2).
7. 1951-1993 Line	Obtained from Fisheries and Oceans Canada, British Columbia Catch Statistics Annual Reports which summarize catch from sales slip records. Catches were reported as dressed weight, DW (head and viscera removed; Wilby 1937), and converted to round weight, RW, using the formula RW = 1.39 * DW (K. Rutherford, Pers. Comm.). Catches for 1982-1993 were reported as round weight, but included the conversion factor for reference.
8. 1954-1995 Canadian Trawl	Obtained from the groundfish catch database, GFCatch (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit). Catch data based on logbook records (source 1, catch and effort data) and/or sales slip records (source 2, no effort data).
9. 1954-1955 United States Trawl	Ketchen (1976).
10. 1956-1982 United States Trawl	Pacific States Marine Fisheries Commission, PSMFC (Will Daspit, Pers. Comm.). Prior to 1975 PSMFC reported Canadian and U.S. trawl data in combined format; therefore for 1954-1974, U.S. catch was determined by subtracting Canadian catch from the combined catch.
11. 1994-1995 Line	Obtained from the sales slip database, PacHarv3 (Fisheries and Oceans Canada, Pacific Region, Catch Statistics Unit).
12. 1996-1999 Line	Obtained from the sales slip database, PacHarv3 (Fisheries and Oceans Canada, Pacific Region, Catch Statistics Unit) and from the Dock-Side Monitored Hook and Line database, PacHarvHL (Fisheries and Oceans Canada, Pacific Region, Stock Assessment Division, Assessment Methods Section).
13. 1996-1999 Trawl	Obtained from the groundfish trawl observer database, PacHarvest (Fisheries and Oceans Canada, Pacific Region, Groundfish Data Unit).

[a] Numbers refer to superscripts throughout Tables 2, 5, 7, 9, and 11 and Appendix I, Table A2

Table A2. Lingcod commercial line, trawl, and total catches (tonnes) for British Columbia [1], 1927-1999. Superscripts correspond to notes and sources of data in Appendix I, Table A1.

Year	Line Catch (t)	Trawl Catch (t)			Total Catch (t)
		Canada	U.S.	Total	
1927	–	–	–	–	2349 [2]
1928	–	–	–	–	2399
1929	–	–	–	–	2265
1930	–	–	–	–	2268
1931	–	–	–	–	2343
1932	–	–	–	–	1837
1933	–	–	–	–	1853
1934	–	–	–	–	2203
1935	–	–	–	–	2920
1936	–	–	–	–	3195
1937	–	–	–	–	1957
1938	–	–	–	–	2179
1939	–	–	–	–	2201
1940	–	–	–	–	2321
1941	–	–	–	–	1933
1942	–	–	–	–	2027
1943	–	–	–	–	2981
1944	–	–	–	–	4023
1945	3278 [3]	630 [4]	–	630	3908
1946	3070	659	–	659	3729
1947	3632 [6]	243	–	243	3875 [6]
1948	6135	451	–	451	6586
1949	6526	737	–	737	7263
1950	3851	787	–	787	4638
1951	1808 [7]	850	–	850	2658
1952	1980	507	–	507	2487
1953	1377	370	–	370	1748
1954	1874	597 [8]	652 [9]	1249	3123
1955	1525	776	1150	1926	3451
1956	1856	1115	936 [10]	2051	3907
1957	2008	985	973	1958	3966
1958	1749	961	902	1863	3612
1959	1495	1132	1730	2862	4356
1960	1659	1078	1834	2912	4571
1961	1545	1308	1772	3080	4625
1962	1761	950	1353	2303	4064
1963	1440	648	941	1589	3028
1964	1151	1280	1121	2401	3552
1965	1104	1741	1899	3641	4744
1966	1212	2000	2489	4489	5701
1967	1320	1889	2392	4280	5600
1968	1125	2920	2378	5298	6423
1969	1323	1818	1327	3145	4467
1970	1483	1439	983	2422	3905
1971	1158	1554	727	2281	3439
1972	1235	1038	504	1542	2777
1973	844	1204	567	1771	2615
1974	938	1506	820	2326	3264
1975	873	1894	836	2730	3603
1976	856	1367	828	2195	3051
1977	961	1175	357	1532	2493
1978	895	907	33	941	1836
1979	977	1159	86	1245	2222
1980	831	1315	56	1370	2202
1981	821	1739	12	1751	2572
1982	957	2878	0	2878	3834
1983	787	2992	–	2992	3779
1984	724	2971	–	2971	3695
1985	813	4853	–	4853	5666
1986	900	2925	–	2925	3825
1987	1184	2400	–	2400	3584
1988	936	2521	–	2521	3457
1989	921	3059	–	3059	3980
1990	1167	4048	–	4048	5216
1991	1171	4211	–	4211	5381
1992	1125	3248	–	3248	4373
1993	1462	3764	–	3764	5226
1994	1223 [11]	3431	–	3431	4654
1995	1097	3110	–	3110	4207
1996	688 [12]	1761 [13]	0	1761	2449
1997	756	1038	0	1038	1794
1998	876	1151	0	1151	2027
1999	1027	960	0	960	1987

Appendix II: Management and quota history for British Columbia lingcod

Table A3. Management history for British Columbia lingcod

a) Commercial Fishery

Year	Event
1920s	Start of 4B winter closure in the Gulf Island region (Dec. to Feb.).
1942	Start of coastwide size limit of 58 cm.
1979	Extension of 4B winter closure (Nov. 15 to Apr. 15).
1987	Start of mandatory logbooks; start of winter closures in 3C/3D/5A offshore (Jan. 1 to Apr. 15) and 3C/3D inshore (Nov. 15 to Apr 15).
1988	Extension of 3C/3D/5A offshore and inshore winter closures (Nov. 15 to Apr. 30).
1989	Extension of 4B size limit to 65 cm.
1991	First year-round closure in Strait of Georgia.
1993	Start of Dockside Monitoring Program.
1996	Extension of coastwide size limit to 65 cm; suspension of trawl winter closure; start of trawl observer program, bycatch limits for halibut, and counting of all quota species including discards against vessel period limits.
1997	Switch to April 1 – March 31 fishing year; 1st individual vessel quota (IVQ) year; expansion of dockside monitoring program and hail out requirements to include all Schedule II trawl licenses except when landed with salmon.

b) Recreational Fishery

Year	Event
1979	Start of 4B winter closure (Nov. 15 to Apr. 15).
1991	Extension of 4B winter closure (Oct. 1 to May 31); start of 4B size limit of 65 cm.
1992	Start of 3C/3D winter closure (Oct. 1 to May 31).
1999	Start of 3C/3D size limit of 65 cm.

Table A4. Yield options and recent commercial TACs and catches for lingcod in British Columbia.

Area	Data Available	2001/02 Recommended Yield	2000/01 Commercial TAC	1999/2000 Commercial TAC	1999/2000 Commercial Catch	Previous Yield Options
4B	• Creel	Continued closure	0	0	0	• Continued closure (Beamish et al. 1995) • Closed in 1991 (Richards and Hand 1991)
3C	• Creel • CPUE • Age composition	≤ 1000 t	950 t	950 t	558 t	• ≤ 1000 t (Leaman and McFarlane 1997)
3D	• CPUE	400-800 t	400 t	400 t	436 t	• No change in yield options (Leaman and McFarlane 1997) • 400 t (low risk) to 800 t (high risk) (Richards and Yamanaka 1992)
5A/B	• CPUE • Age composition	≤ 1100 t	1062 t	1062 t	749 t	• No change in yield options (Leaman and McFarlane 1997) • 1100 t (low risk) to 2200 t (high risk) (Richards and Yamanaka 1992)
5C/D	• CPUE	} ≤ 1000 t	1000 t	1000 t	596 t	• 1000 t (Leaman and McFarlane 1997)
5E	• None					